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TECHNICAL REPORT
NATICK/TR-91/043

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DEVELOPMENT OF THE THERMOSTABILIZED MEAL TRAY

By
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July 1991

Final Report
October 1985 - December 1990

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
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FOOD ENGINEERING DIRECTORATE

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13. ABSTRACT *(Maximum 200 words)*

The Thermostabilized Meal Tray (TMT) was developed to fulfill an Air Force need for an individual, shelf stable, fully prepared meal to service small groups for one to five days. Targeted user groups were surveyed to determine the types of meals, menu cycle, performance and heating characteristics required for this feeding system. Various retortable, high barrier polymeric trays and lidding materials were tested for performance characteristics. Products were formulated and tested for acceptance and long term storage stability. A five day nutritionally complete menu cycle, consisting of 15 meals, was developed. Contracts were awarded to test producibility. A complete packaging system was designed to include an entree, starch or vegetable, and dessert components assembled in an outer compartmented polymeric serving tray. TMT products may be heated by a microwave oven, by hot water submersion, or by an induction type fabric heater. The TMT was successfully field tested by Air Force personnel and specifications were prepared. Potential users include Rail Garrison Crews, Missile Support Crews, Security Forces and Combat Vehicle Crews.

14. SUBJECT TERMS

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PREFACE

The following is a final technical report covering the development of the Thermostabilized Meal Tray (TMT). This report covers all efforts conducted during the period of October 1985 through December 1990.

U.S. Army Natick Research Development and Engineering Center (Natick) Project Officers for the TMT project during its various stages of development were Ms. Nancy Kelley and Ms. Lauren Oleksyk of the Food Engineering Directorate (FED), and Ms. Angela Fong, formerly of FED. The technical support required for the successful development of the TMT was provided by Mr. Jay Jones and Ms. Jeanne Ross of the Subsistence Protection Branch, FED.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

ABBREVIATIONS, ACRONYMS AND SYMBOLS

ADA	Air Defense Artillery
ASCID	Advanced Systems Concepts Integration Directorate
AF	Air Force
AFB	Air Force Base
AQL	Acceptable Quality Level
ASTM	American Society for Testing & Materials
BSD	Behavioral Science Division
CPV	Command Post Vehicle
CVC	Combat Vehicle Crew
DoD	Department of Defense
EPS	Experimental Packaging Section
EVOH	Ethylene Vinyl Alcohol Copolymer
FDA	Food & Drug Administration
FED	Food Engineering Directorate
FESD	Food Equipment Systems Division
FI	Food Innovisions, Inc.
FSIS	Food Safety Inspection Service
JTS	Joint Technical Staff
MI	Military Intelligence
MRDA	Military Recommended Dietary Allowances
MRE	Meal, Ready-to-Eat
Natick	United States Army Natick Research, Development and Engineering Center
NFPA	National Food Processors Association
OFIG	Operational Forces Interface Group
OTSG	Office of The Surgeon General
PARS	Product Assessment Review Summary
PP	Polypropylene
PVDC	Polyvinylidene Chloride
PY	Polyester
RI	Rockwell International
SAC	Strategic Air Command
SCS	Satellite Communications Squadron
SPB	Subsistence Protection Branch
SSD	Soldier Science Directorate
TMT	Thermostabilized Meal Tray
USDA	United States Department of Agriculture
F_O	Sterilizing value
F	Twenty inch pounds of force
H	Height in inches
Hg	Mercury
T_I	Initial temperature
W	Weight of tray
in	inches
lb	pounds
min	minutes
oz	ounces
psig	pounds per square inch gauge
s	seconds

SUMMARY

The Thermostabilized Meal Tray (TMT) is a fully prepared, single serving, shelf stable meal designed to provide a dining hall type of meal to personnel in remote locations. Each meal consists of three individually processed components: an entree, a starch or vegetable and a dessert. The meal components are thermally processed in high-barrier polymeric trays with hermetically sealed foil laminated lids, and are assembled into an outer compartmented plastic tray for transporting, containing and serving the meal. The TMT may be heated by microwave, by submersion in hot water or with an induction type fabric heater. When supplemented with a fortified beverage base, the meals are nutritionally complete. A five day menu cycle provides fifteen nutritionally complete meals, five each of breakfast, lunch and dinner. Potential users include Rail Garrison Crews, Missile Support Crews, Security Forces, Combat Vehicle Crews and Infantry Division Units (Light).

DEVELOPMENT OF THE

THERMOSTABILIZED MEAL TRAY

INTRODUCTION

The concept of thermostabilized food in semirigid polymeric trays was introduced by food industries worldwide in the early 1980's. During this time, shifting demographics resulted in significant changes in food packaging requirements. Dual-career families, single-parent families and the proliferation of microwave ovens resulted in a trend away from prepared, sit-down family dining toward the convenience style of prepared meals to facilitate eating on the run. Along with these changes in consumer life-styles, food processors, facing increasing consolidation and competition, were looking urgently for products and processes that would reduce their manufacturing and distribution costs. The function of the package took on growing importance in how food was prepared and sold.

Food industries rapidly began developing high barrier, retortable polymeric trays which met consumer demands for shelf stable products with microwave convenience and upscale quality. Industry began to design and install packaging equipment capable of coextruding, thermoforming, filling and sealing polymeric trays. The Food and Drug Administration (FDA), United States Department of Agriculture (USDA), American Society for Testing and Materials (ASTM) and other regulatory agencies immediately began establishing guidelines for retortable semirig[illegible]ric trays.[1]

By 1985, thermoprocessed food in semirigid polym[illegible] trays

represented state-of-the-art technology in food industries worldwide. At this time,several events occurred. First, the Air Force submitted to the United States Army Natick Research, Development and Engineering Center (Natick) a letter of requirement which stated the following:

> A food service system is needed to provide a complete meal, to fill a gap between a dining hall meal and an operational ration, for personnel such as missile support crews and security forces in remote areas. The meal must be designed to be complete, shelf stable, heated individually, and presented in a familiar configuration similar to a dining hall meal.

Second, the possibility of providing a microwave device for heating field rations was being considered for use in the future field feeding concepts of ARMY 21. The Air Force, in fact, had microwave capability for the personnel mentioned above. Taking the past developmental efforts and current technology into consideration, a program was established to address the Air Force requirement.

The principal objective was to design and develop an individual, thermally processed, ready-to-eat meal which would not require preparation other than heating, would not require refrigeration, and would be packaged in an outer tray which also functioned as a serving unit. The meal was intended to improve food service for remote area personnel and combat vehicle crews (CVC) by providing a meal similar to that served in a dining hall.

In this developmental period, extensive literature searches revealed that rations were either designed for multiple service (Tray Pack) or single service (pouched components packaged in individual meal bags such as the Meal, Ready-to-Eat [MRE]). The MRE pouched foods were not self-standing or in a configuration familiar to the soldier. In order to meet the above stated AF needs, research and development of the Thermostabilized Meal Tray (TMT) was initiated.

DEVELOPMENTAL APPROACH

A detailed technical approach to developing the TMT was formulated. It included conducting a survey of targeted Air Force (AF) user groups to determine requirements for the feeding system, including intended feeding scenarios, types of meals required, menu cycle and performance and heating requirements. A literature search was conducted to review various forms of polymeric packaging that were currently being used for shelf stable foods. Several retortable trays and lidding materials were obtained from industry and evaluated to determine suitability to user requirements. Tests were conducted to examine the following: performance of retort trays and lids, which included their ability to withstand retorting and rough handling (vibration, drop); immediate tray abuse following rough handling; seal strength and burst strength determination; microbiological determination of commercial sterility after retort; methods of heating; and ease of producibility on a large scale production. Food products were formulated specifically for processing in polymeric trays by adapting and modifying existing MRE and Tray Pack product formulations. Acceptance tests were conducted by consumer and technical panelists throughout a three year storage study to determine shelf life of TMT products. Limited user tests were conducted to evaluate the various methods of heating the TMT, to obtain acceptance data on the TMT concept at different stages in its development, and to examine if unique requirements existed in specific scenarios. A nutritional analysis was conducted on a variety of 15 different meals. A final prototype system was assembled, and verification

tests were conducted by the Air Force in the intended remote site locations. Methods of testing the components of the TMT at various stages of development are outlined in Sections I through VIII in the Test Protocol.

TEST PROTOCOL

I. Performance Testing of Lidding Materials

Commercially available lidding materials were tested to determine their performance characteristics, including the ability to withstand retorting and rough handling, and to determine the seal strength to the tray.[2] Polymeric retortable trays manufactured by Ball Corporation were filled with 8.0 ounces of water at 70°F. Five types of lidding materials were evaluated. Three types were composed of polyester (PY), foil and polypropylene (PP), and the two other types contained a non-foil laminate of polyvinylidene chloride (PVDC). Seventy-two lids of each material were heat sealed to the Ball trays on a Reycon Model 103 laboratory vacuum sealer. The chosen level of vacuum was the highest vacuum obtainable without causing wrinkles in the seals area. The lidding materials tested are outlined in Table 1. All lids were sealed at 375°F

Table 1. Lidding Materials

Structure	Manufacturer	Vacuum
Retort pouch material PY[a]/foil[b]/PP[c]	Reynolds	18 in Hg
Non-foil barrier (transparent) PY/PVDC/PP	Ludlow	28 in Hg
Non-foil barrier (opaque) PY/PVDC/PP	Ludlow	24 in Hg
Peelable PY/foil/PP	Reynolds	22 in Hg
Break and peel PY/foil/PP	Reynolds	22 in Hg

[a] PY layer = 0.0005 inches thick
[b] aluminum foil layer = 0.00035 to 0.0007 inches thick
[c] PP layer = 0.003 to 0.004 inches thick

with 36 pounds per square inch (psig) of pressure with a 1 second dwell time. Results are recorded in the Results and Discussion Section.

RETORTING: All trays were retorted at 240°F, 20 psig for one hour in a still retort with water medium, to sterilize water in trays. Trays were randomly placed in a metal retort rack to eliminate variability caused by inconsistent heat distribution within the retort.

VIBRATION AND DROP TEST: The rough handling tests conducted on the sealed retorted trays (modified ASTM test methods) were based on accepted military standards for the retort pouch.

Thirty-six trays were packed per shipping container. The shipping containers were fabricated from V3c fiberboard, which is most commonly used for military shipping and storage of subsistence items. The packing configuration consisted of four tiers of nine trays with die-cut partitions separating each tray and pads separating each tier. This configuration was chosen for its vertical strength, to prevent abrasion between trays, and for optimal container dimensions and weight for carrying and handling. ASTM D999 was followed for the vibration test, with the frequency set at 268 RPM for one hour.[3] After the vibration cycle, each shipping container was dropped from a height of 21 inches in the following sequence, according to ASTM-D775, objective B[4]:

(1) A corner drop on the 5-1-2 corner. (see Figure 1)

(2) An edge drop on the shortest edge radiating from the corner.

(3) An edge drop on the next shortest edge radiating from that corner.

(4) An edge drop on the longest edge radiating from that corner.

(5) A flatwise drop on one of the smallest faces.

(6) A flatwise drop on the opposite smallest face.

(7) A flatwise drop on one of the medium faces.

(8) A flatwise drop on the opposite medium face.

(9) A flatwise drop on one of the large faces.

(10) A flatwise drop on the opposite large face.

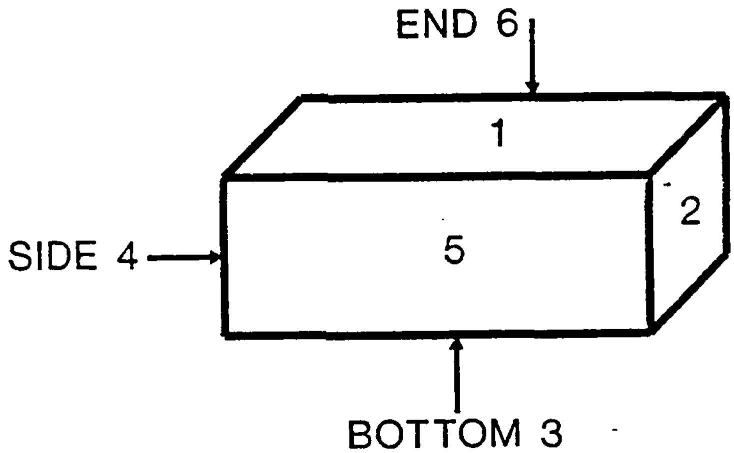

Figure 1. Drop Test of Shipping Container

IMMEDIATE TRAY ABUSE TEST (USDA): The USDA procedure for immediate tray abuse was followed to test each individual retorted tray. A test apparatus was fabricated consisting of a chute that is inclined at an angle of 15° from the vertical and having a rigid base plate at a 90° angle to the direction of the fall (see Figure 2). The height of the drop was adjusted so that the tray struck the base plate with a force of 20 inch-pounds. This height is calculated from the formula, $H = \frac{F}{W}$, where H is the height in inches, W is the gross weight of the tray in pounds and F is 20 inch-pounds. The Ball tray was dropped on two opposite edges from a

height of 36 inches. As part of the USDA immediate tray abuse test, each tray was subjected to an internal pressure test following the initial drop.

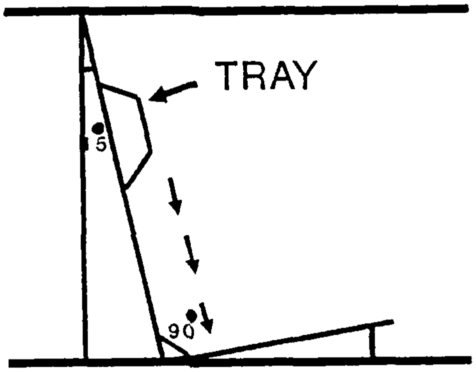

Figure 2. Immediate Tray Abuse

INTERNAL PRESSURE TEST: This test is designed to evaluate a lidding material's ability to withstand high pressure conditions, while maintaining a hermetic seal to the polymeric tray. The internal pressure test was performed on each tray while submerged in water. During testing, an appropriate restraining device was applied to each tray to prevent it from floating to the top of the test chamber. Air pressure was introduced into the tray by means of a hypodermic needle attached to a controlled air pressure system with pressure gauge and needle valve. The needle punctured the tray through a sealant compound that provides a septum seal. The sealant used was General Electric Sealant RTV-108. The tray was submerged and air was introduced. When five psig internal pressure had been reached, the tray was held for a minimum of 60 seconds under water. If a pressure drop occurred, a steady stream of bubbles was observed, the tray burst, or any seal yielded more than 1/16 of an inch,

the tray failed the internal pressure test and was not subjected to further testing.

SEAL STRENGTH TEST: ASTM F88 was followed to determine seal strength after rough handling.[5] This test method does not measure seam continuity or any other property beyond the force required to tear apart a seal from a tray sample of standard width. Four 1/2 inch wide samples were cut from each seal from each test tray. Samples were tested for seal tensile strength on an Instron Universal Testing Instrument, table model 1130. Seal strengths were recorded in lb/inch for each sample tested.

II. Performance Testing of Coextruded Polymeric Trays

Tests were conducted to compare the performance of four different retortable polymeric trays filled with product and sealed with a tri-laminate lid of retort (MRE pouch) material, which was shown to perform optimally in previous tests.[6] Each tray was constructed from a seven layer coextruded sheet composed of an inside and outside structural layer of polypropylene (PP), two regrind layers, two adhesive layers, and a middle barrier resin layer as illustrated in Figure 3. The barrier resin layer in two of the four types of trays was composed of a polyvinylidene chloride copolymer (PVDC), and in the other two trays an ethylene vinyl alcohol copolymer (EVOH). The regrind layers consist of PP and barrier polymer. The trays are microwaveable and were commercially available stock items ranging in capacity from 5.0 to 11.0 ounces. Tray manufacturer, structure, dimensions, flange width and capacity are listed in Table 2.

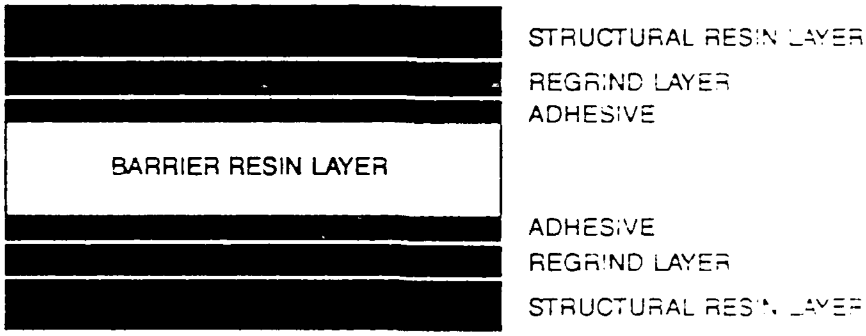

Figure 3. Composition of Tray Material

Table 2. Tray Specifications

Tray Manufacturer	Structure	Dimensions, in	Flange Width, in	Capacity
DRG (Hercules)	PP/EVOH/PP	5-1/2 x 3-7/8 x 1-1/4	5/16	10.0 oz
Owens (rect)	PP/PVDC/PP	5-1/2 x 4-1/4 x 1-1/4	1/2	11.0 oz
Owens (square)	PP/PVDC/PP	4-1/2 x 4-1/2 x 1	5/16	5.8 oz
Rampart	PP/EVOH/PP	4-3/4 x 3-1/8 x 1-1/2	3/16	8.0 oz

Two hundred polymeric trays, of each of the four types to be evaluated, were filled with a previously prepared product that had been heated for 1 hour at 180°F. The fill weight varied for each style tray allowing 1/4" headspace. Lids of retort pouch material (polyester/foil/polyolefin) were heat sealed to the trays on a Reycon Model 103 laboratory vacuum sealer. Each tray was sealed under 22 Hg to obtain maximum vacuum without contaminating the seal area with product. Sealing parameters and fill weights are listed in Table 3.

Table 3. Tray Preparation

Tray	Fill Weight	Sealing Parameters ^oF	psig	dwell time
DRG (Hercules)	11.0 oz	350	60	1 s
Owens (rect)	12.0 oz	350	70	4 s
Owens (square)	5.6 oz	375	60	1 s
Rampart	8.3 oz	350	40	2 s

RETORTING: All trays were retorted at 240°F, 20 psig for a sufficient length of time to attain a product lethality, F_o, between 6 and 8.

VIBRATION AND DROP TEST: Shipping containers for the food trays were designed to hold a constant weight, rather than a constant number of trays, since the fill weight of the four tray styles ranged from 5.6 to 12 ounces. The containers were constructed from V3c fiberboard, with die-cut partitions separating each food tray, and pads separating trays into four tiers. Shipping container arrangements are listed in Table 4.

Table 4. Shipping Container Arrangements

Tray	Tier Arrangement
DRG (Hercules)	2 trays x 3 trays
Owens (rect.)	2 trays x 3 trays
Owens (square)	3 trays x 3 trays
Rampart	3 trays x 3 trays

The shipping containers and contents were tempered at $72^{\circ}F$ or $-20^{\circ}F$ for 24 hours to equilibrate test samples to the same climatic conditions prior to rough handling testing. ASTM D999-75 was followed for the vibration test, with the frequency set at 268 RPM for one hour. Following vibration testing, each shipping container was dropped from a height of 21 inches according to the sequence described in ASTM D775-80, objective B. For those containers tempered at $-20^{\circ}F$, drop testing was conducted prior to vibration testing. Each food tray was examined after rough handling. All trays tempered at $72^{\circ}F$ passed vibration and drop tests, however a wide range of performance was found in trays tempered at $-20^{\circ}F$. Those trays with no evidence of damage were further tested according to the USDA test method for immediate tray abuse.

IMMEDIATE TRAY ABUSE TEST: The USDA method for immediate abuse test was used to test trays, however, in this test the drop height varied for different weight trays to allow each tray to strike the base plate with a force of 20 inch pounds. The drop height for each tray type is listed in Table 5. Subsequent to this immediate tray abuse, trays which successfully withstood the drop were further subjected to the internal pressure test.

Table 5. Drop Height for Immediate Tray Abuse

Tray	Drop Height, in
DRG (Hercules)	28.2
Owens (rect.)	26.1
Owens (square)	55.7
Rampart	38.4

INTERNAL PRESSURE TEST: The USDA method for internal pressure test was performed on the four sample trays while submerged in water at 23°C. All trays withstood the internal pressure test and were subsequently tested for seal strength between tray and trilaminate lidding material.

SEAL STRENGTH: ASTM F88 was followed to determine seal strength after the above tests had been conducted. Seal strengths after rough handling were compared to those obtained initially on trays that were not rough handled.

TRAY BURST STRENGTH TEST: Burst strength tests were conducted on two types of polymeric semirigid trays with tri-laminate heat-sealed lids (MRE retort pouch material).[7] The two types of trays tested were the DRG (Hercules) 11.0 ounce and the Rampart 8.0 ounce trays described in Table 2. These trays were chosen because they performed optimally in all previous tests. Both types of trays contained water and were sealed individually on the Reycon Model 103 laboratory vacuum heat sealer and were retorted at 240°F at 20 psig. The burst tests were conducted on the SKYE 1520S Seal Strength/Burst Tester manufactured by MOCON (Figure 4).

Air pressure was introduced into sample trays by means of a hypodermic needle attached to a controlled air pressure system. A self adhering septum is used to provide an air tight passageway between the needle and the package lid material. The rate at which air was introduced into the sample trays was approximately 1 pound per second. Trays were supported on a base plate but were not restrained at the time air was

introduced. The pressure at which the package burst was recorded as the burst strength. Each tray was examined immediately after rupturing to determine if failure was a material or a closure seal failure.

Figure 4. MOCON Burst Tester

III. Post Retort / Sterility Testing

Filled and sealed trays of various products were thermoprocessed in accordance with the sterilization and internal temperature requirements listed in Table 6. Products were formulated specifically for use with the state-of-the-art polymeric trays. This was done by adapting and modifying existing MRE and Tray Pack product formulations. The processing parameters were established by incorporating NFPA suggested guidelines,

thermoproperties inherent in TMT products, the configuration and make-up of the polymeric trays, and Traycan and MRE product processing requirements. All starch, vegetable and dessert items were processed in 8.0 ounce trays manufactured by Rampart. All entrees were processed in 10.5 ounce DRG trays.

Table 6. Thermoprocessing Parameters

Food Product	Net Weight, oz	Retort Sterilization Requirement
Applesauce	8.5	Initial temp. $\geq 195^{\circ}F$
Sliced Peaches	8.0	"
Sliced Pears	8.0	"
Fruit Mix	8.0	"
Apple Dessert	8.0	"
Chocolate Pudding	8.0	F_o not less than 8.5
Potato au Gratin	8.0	F_o not less than 6.0
Rice	8.0	"
Chicken Stew	11.5	"
Chicken ala King	11.5	"
Beef Stew	11.5	"
Beef Strips w/ GP	11.5	"
Chili con Carne	11.5	"
Diced Ham w/ SP	11.5	"
Ham Slices	11.0	"
Pork BBQ Sauce	11.5	"
Spaghetti w/ Meat	11.5	"
Tuna w/ Noodles	11.5	"
Corned Beef Hash	11.5	"
Ham Omelet	11.5	"
Breakfast Bake	11.5	"
Western Omelet	11.5	"
Buttered Potatoes	8.0	F_o not less than 5.6
Hominy Grits	8.0	F_o not less than 9.0
Corn	8.0	F_o not less than 9.6
Green Beans	8.0	F_o not less than 3.4
Carrots	8.0	F_o not less than 4.2
Green Peas	8.0	F_o not less than 7.2
Macaroni w/ Cheese	8.0	F_o not less than 6.0
Chicken Breast(Gravy)	11.0	F_o not less than 6.0
Hamburger Patties	11.0	F_o not less than 6.0

Trays were restrained during retorting by placing them in metal retort racks designed specifically for the polymeric trays. The distance between the restraining surface and the top surface of each tray did not exceed 1/4 inch. All surfaces of the retort rack which contacted the trays were free from any surface aberrations (such as burrs, sharp edges, etc.) that might cause excessive stress to trays during processing. The sterilizer used was a full water immersion retort with air pressure override. Overriding air pressure was maintained throughout the entire processing and cooling cycles to prevent straining of the tray body and closure seal. The time, temperature and pressure of the complete processing and cooling cycle was recorded. With the exception of hot fill products (195^{o}F), products were retorted at appropriate temperatures, ranging from 220^{o}F to 240^{o}F, until their commercial sterilization lethality values (F_o) were achieved.

After thermoprocessing, trays were visually examined for defects and tested for residual gas volume, leakage, burst strength and commercial sterility. These test methods are described as follows:

RESIDUAL GAS VOLUME TEST: The volume of residual gases was determined by water displacement. Trays that were originally sealed under a 24 to 28 inch vacuum were opened under 75$^{o}\pm$5^{o}F water and the gases were collected by water displacement in a graduated cylinder. The volume of gases were reported to the nearest 0.1 cubic centimeter.[8] Any tray with a residual gas volume exceeding 10.0 cubic centimeters was a critical defect and was considered to be a test failure.

LEAKAGE TEST (ASTM D3078)[9]: Each filled, sealed and thermally

processed tray was submerged in water in a transparent vacuum chamber that is capable of withstanding a pressure differential of one atmosphere. The vacuum chamber was fitted with a flat, vacuum-tight cover. A vacuum gauge, an inlet tube from a vacuum source, and an outlet tube to the atmosphere were sealed into the cover. The inlet and outlet tubes were equipped with hand valves. Attached to the underside of the cover was a transparent plate that closely approximated the inside diameter of the tray. The vessel was 2/3 filled with water. The plate was positioned to hold the sample submerged one inch under water. The cover was set on the chamber, the outlet valve closed and the vacuum turned on. The vacuum pressure in the chamber was increased steadily for approximately 2 minutes or until 27 inches of mercury was reached. The vacuum was held for a minimum of 30 seconds. During the rise in vacuum and the hold time, the submerged sample was observed for leakage in the form of a steady progression of bubbles. Isolated bubbles caused by entrapped air were not considered to be leaks. Any leakage was considered a critical defect.

BURST STRENGTH TEST: One retorted tray per retort rack was selected and held for 48 hours after processing in accordance with the USDA test method for internal pressure (burst strength The tray was submerged in water, held in place and air was introduced at 10 psig and held for 60 seconds. At completion of test, if tray did not burst, seals were examined for separations not to exceed 1/16 in. Any seal separation greater than this or any tray that burst was considered a critical defect.

STERILITY TEST: The filled, sealed and thermoprocessed trays were tested for commercial sterility. Samples of trays were incubated at

$30^{o}C$ for 10 days, as specified by the Food Safety Inspection Service (FSIS), by the Microbiology Branch of the Soldier Science Directorate (SSD) at Natick. Following incubation, products were subjected to microscopic examinations including aerobic plate counts, yeast and mold counts. Plate counts which indicated questionable sterility, or evidence of tray swelling or off-odor were considered critical defects.

Sample trays that failed any post-retort tests were categorized as critically defective, as recommended in NFPA guidelines for polymeric trays.

IV. Methods of Heating

Heating capabilities that were available to personnel in various field scenarios were identified in the survey of potential users. Post-retorted TMT's were therefore examined in-house for the ability to be heated by microwave oven, hot water submersion, and an induction type fabric ration heater. The fabric ration heater was designed to operate off the combat vehicle's power supply. Heating elements are embedded in the unit's shelves and walls, and the fabric housing provides insulation. This particular unit was actually designed for use with Tray Packs, but could hold two or three TMT components per shelf depending on the size of the trays being heated. The time it took for each method to bring the TMT products to optimal serving temperatures (110 to $140^{o}F$) was recorded. Any special heating instructions required by a particular method was also noted.

V. Producibility Testing

Requirements for tray performance and thermoprocessing were established after the completion of in-house testing of various trays, lidding materials and product formulations. Initial technical data packages were written for the production of TMT's and included a variety of product formulations, packaging, thermoprocessing and quality assurance testing requirements. Two contracts were awarded to industry to test the producibility of TMT's in large quantities and to provide Natick with a sufficient supply of TMT's for shelf life testing.

The first contract was awarded to Wornick Services, Inc. in Houston, Texas. It involved the production and thermoprocessing of individual servings of food packaged in microwaveable polymeric trays. The items and quantities that were produced are listed in Table 7. Quantities varied based on the projected assembly of products into various menus.

Table 7. Wornick Produced TMT's

Products	Quantity, trays
Fruit Mix	1700
Sliced Peaches	2600
Sliced Pears	1700
Chocolate Pudding	4400
Potatoes au Gratin	1700
Rice in Butter Sauce	2600
Beef Stew	800
Beef Strips w/ Green Peppers and Gravy	800
Chicken ala King	800
Spaghetti w/ Meat Sauce	800

Wornick processed the products in barrier trays constructed of a five-layer coextrusion of polypropylene, adhesive layer, EVOH barrier layer, adhesive layer and polypropylene. The lid material was a three-ply

laminate of .004" polypropylene film, .0007" aluminum foil and .0005" polyester external film (MRE retort material). Entrees were packaged in 10.5 oz thermoformed rectangular trays manufactured by DRG (formerly Hercules trays), and starch and dessert items were packaged in 8.0 ounce rectangular trays made by Rampart. Complete formulations, filling, sealing and thermoprocessing parameters and equipment used are listed in Natick TR-88/060 "Production of Retorted Meals in Coextruded Barrier Trays".[10]

The second producibility contract was awarded to Food Innovisions, Inc. (FI) in Harahan, Louisiana. The objective of this contract was to produce a variety of TMT foods, different from those processed by Wornick. The items and quantities produced are listed in Table 8.

Table 8. FI Produced TMT's

Products	Quantity, trays
Chicken Stew	500
Chili con Carne	500
Diced Ham w/ Scalloped Potatoes	500
Ham Slices	500
Pork in BBQ Sauce	500
Tuna with Noodles	500
Ham Omelet	250
Breakfast Bake w/ Sausage	250
Corned Beef Hash	250
Western Omelet	250
Applesauce	500
Apple Dessert	1000
Hominy Grits	500
Potatoes in Butter Sauce	500
Corn	100
Green Beans	100
Carrots	100
Green Peas	100

FI TMT's were processed in barrier trays constructed of a six-layer coextrusion of PP, adhesive, PVDC or EVOH, reclaim, adhesive, PP. The lid

material used was a tri-laminate consisting of a .0015" PE sealant layer, .0017" aluminum foil, and .0005" PY external layer. The entrees were packaged and processed in 11.5 ounce rectangular trays thermoformed with handles, and the starch, vegetable and dessert items were processed in 8.0 ounce round bowls with handles. Both trays and lidstock were manufactured by Genesis Packaging Systems. FI was unable to obtain the exact trays specified in the TDP, and were given approval by Natick to use the Genesis trays. The Genesis trays were constructed of similar food grade materials as those used by Wornick (DRG and Rampart trays) and differed only in style and the type of equipment required to heat seal them. However, since these trays did not meet tray configuration requirements and would not be used in future assemblies, performance tests were not conducted on any Genesis trays. Complete product formulations, filling, sealing and processing parameters and equipment used are listed in FI final report titled "Production of Foods in Retortable Barrier Polymeric Trays".[11]

Both contractors were responsible for examining TMT's for visual defects, net and drained weights, residual air, burst strengths and sterility. Both were required to submit retort records to verify that the sterilization of each product was achieved. After products were submitted to Natick they were incubated by the Microbiology Branch to verify that commercial sterility was achieved. Sample trays, lidding material and product quality were examined by SPB. Remaining TMT's were placed in controlled and adverse storage environments for a long term storage study and acceptance testing.

VI. Product Acceptance / Shelf Life Testing

Contract produced TMT products were evaluated by consumer andtechnical panelists for sensory attributes including appearance, odor, flavor, texture and overall quality. Taste panels were held on all products initially, then approximately every six months throughout a three year storage study. TMT's were stored at 80^{O}F and 100^{O}F. The barrier properties of EVOH and PVDC polymers are known to change at high temperatures, increasing the permeability of oxygen and water vapor, and decreasing the quality of the product. Therefore, products stored at both temperatures were comparatively evaluated at taste panels to examine the stability of products at high temperatures. A specific shelf life for the TMT was not required in the AF statement of need. However, operational rations developed in accordance with requirements for other services normally require a shelf life of 3 years at 80^{O}F and 6 months at 100^{O}F. The TMT storage study was designed to examine product stability at these shelf life requirements. The three year storage study is ongoing and is scheduled for completion in December 1991.

TMT products were also examined for nutritional composition. Nutrient analyses were conducted on all products listed in Tables 7 and 8, and on additional items formulated after producibility tests, including hamburger patties, chicken breast and macaroni and cheese. These analyses provided a basis for selectively combining entree, starch or vegetable and dessert items that together provide a meal which meets military recommended dietary allowances (MRDA) (Appendix A). A five day menu cycle was developed that provides five each of breakfast, lunch and dinner meals for a total of 15 different meals. Meals (No. 1-15) are listed in Table 9.

Table 9. TMT Menu Cycle

	Components		
	Entree	Starch/Vegetable	Dessert
Breakfast Meals			
1	Diced Ham w/ Potatoes	Applesauce	Peach Slices
2	Ham Omelet	Potatoes	Pear Slices
3	Corned Beef Hash	Hominy Grits	Applesauce
4	Breakfast Bake	Potatoes	Pear Slices
5	Western Omelet	Hominy Grits	Peach Slices
Lunch Meals			
6	Chili con Carne	Rice	Apple Dessert
7	Hamburger Patties	Mac & Cheese	Choc. Pudding
8	Tuna w/ Noodles	Green Beans	Pear Slices
9	Pork w/ BBQ Sauce	Rice	Apple Dessert
10	Chicken ala King	Carrots	Choc. Pudding
Dinner Meals			
11	Spaghetti w/ Meat	Corn	Choc. Pudding
12	Chix Breast w/ Gravy	Green Beans	Apple Dessert
13	Chicken Stew	Green Peas	Choc. Pudding
14	Beef Stew	Mac & Cheese	Peach Slices
15	Ham Slices	Potatoes	Pear Slices

A compartmented plastic serving tray was designed to contain the three constituents of a complete meal (Figure 5). This outer tray is composed of high density polyethylene and has a snap on lid. It was made an optional feature since some users expressed they did not have a need for it. For example, Rail Garrison Crews have serving trays available, therefore the TMT outer tray would only be an added expense and generate excessive waste. Missile Support Crews would require the outer tray for containerization, transport and for use as a serving tray for the meal at remote locations.

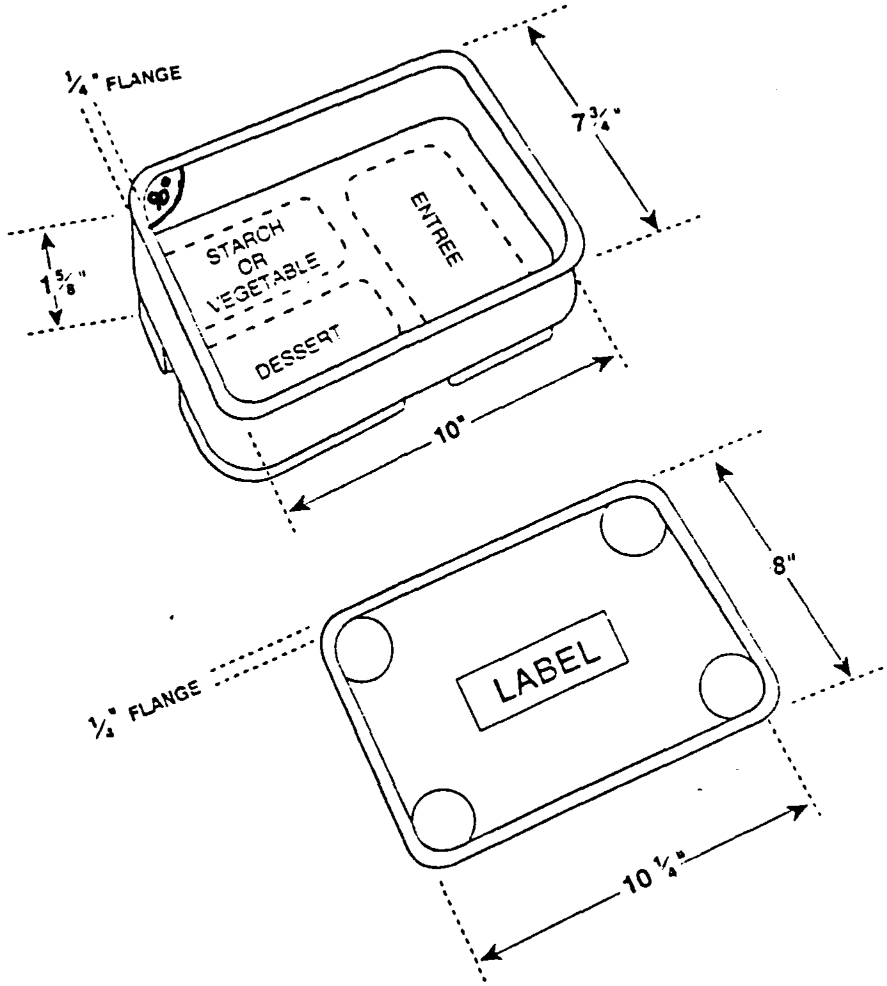

Figure 5. Serving Tray Design

VII. Field Testing

The TMT was demonstrated to potential users from various services during its early stages of its development. The first two of these limited field tests were conducted mainly to demonstrate this new concept in field feeding. However, different methods of heating the TMT, in fabric ration heaters and in microwave ovens, were also examined during these tests.

REDLEG Command Post Vehicle (CPV) Life Support Exercise:

The earliest prototype of the TMT was demonstrated in October of 1985 at the U.S. Army Field Artillery School, Fort Sill, OK.[12] During this 72 hour operational demonstration, small crews were fed three prototype TMT menus while in their combat vehicles. Menu #1 consisted of ham and potatoes, pineapple and chocolate pudding; Menu #2 consisted of ham and egg omelet, corned beef hash and fruit cocktail; and Menu #3 consisted of chicken ala king, rice and peaches. The meal components were retorted, in-house, in trays constructed of coextruded PP/PVDC/PP with retort pouch lidding material. The trays were nested inside the outer compartmented tray. For this demonstration, a dining packet containing eating utensils was attached to the tray so that the plastic knife could be used as an opening tool for the meal components. The TMT's were heated in a fabric ration heater which operates off the vehicle's power supply of a 28-volt direct current. One fabric ration heater was on board each vehicle.

Microwave Field Feeding Technology Demonstration:

In August 1987, the TMT was tested during the Microwave Field Feeding Technology Demonstration with the 7th Infantry Division (Light) Units at Fort Hunter Liggett in Jolon, CA.[13] Three units participated in the demonstration: Military Intelligence (MI), Signal Troops (SN) and Air Defense Artillery (ADA). Three types of shelf stable, microwaveable products were provided to each unit: TMT breakfast, lunch and dinner menus; commercial microwaveable retort pouch entrees; and commercial microwaveable tray entrees that were currently in test market (Hormel's

Top Shelf and General Foods' Impromptu). ADA fed troops in three locations, transporting the microwave oven to each site where the meals were heated and distributed. MI and Signal units had ovens located on site where troops heated their own meals when desired. Questionnaires on the microwaveable meals were completed by the troops.

In September 1989, a more developed prototype of the TMT was ready to be tested by the proposed Air Force users in their unique scenarios. Initially, two limited user tests were conducted on the TMT, in conjunction with other rations, at Holloman Air Force Base (AFB), NM and Rockwell International (RI) in San Bernadino, CA. These limited tests were planned and implemented by the Food Systems Division of Advanced Systems Concepts Integration Directorate (ASCID, formerly ASCD) as part of their overall plan to improve the food service systems at many bases.

Holloman AFB, NM:

A limited variety of TMT's were evaluated by ASCID at Holloman AFB on September 7-8, 1989, as part of a three phase plan to upgrade the food service system at the 4th Satellite Communications Squadron (SCS), Mobile. In Phase I of this plan, improvements were made to the existing SCS menu and in Phase II, frozen foil packed foods were tested. In Phase III, TMT's were served for 1-1/2 days during the SCS security police augmentee training mission. The mission carried 30 people (12-14 more then normal) into the field with the regular crew support vehicles but no mission vehicles. The training simulated several security situations to teach the defenders how to react. Customary meal supplements, snacks and

beverages were provided in addition to TMT's. The crew filled out a one page survey on the TMT's within an hour after returning from the field.

Rockwell International (RI), San Bernadino, CA:

A series of three 48-hour habitability tests were conducted on Rail Garrison Crews on Nov 14-16, Dec 5-7 and Dec 12-14 in 1989. These tests were generated by the results of ASCID's previous participation in a 32 day Rail Garrison Habitability Exercise where they surveyed the Food Service Systems on Security and Launch Control Cars. During each test, various TMT's were provided in addition to frozen foil packed foods, commercial frozen foods and MRE's. TMT meals were provided for lunch and dinner on the first day of each test, and were compared to frozen meals and MRE's served on the other days. All crew members were eating TMT's for the first time. Approximately 15 crew members participated in the sensory evaluations of the TMT's during each 48 hour test and rated their quality on a hedonic scale of 1-7, from very dissatisfied (1) to very satisfied (7).

After final modifications were made to the TMT, a more extensive field test was conducted at Barksdale AFB, LA. This final field test was a planned milestone in the TMT development program.

Barksdale AFB, LA:

The purpose of this test was to determine the acceptability of the final TMT and to examine the concept of providing a "dining hall type meal" in a field environment. The test was supported by the Operational

Forces Interface Group (OFIG), ASCID, the Material Systems Human Factors Branch, SSD, and the AF JTS representative. A Product Assessment Review Summary (PARS) for the Strategic Air Command (SAC) field testing of TMT Rations was prepared, coordinated and approved.[14] The Warrior Training Center at Barksdale AFB was established as the field test site for the 25-28 June 1990 test.

Fifty-five trainees tested 10 TMT meals, including breakfast, lunch and dinner, at a semi-remote location during their week long readiness training program. When TMT's were not provided, other shelf stable rations including MRE's, Tray Packs and B Rations were issued. Bread, beverages and fresh fruit were offered with each meal. The TMT's, which were prepared and processed at Natick, were evaluated for product acceptability, ease of preparation, ease of opening, serving temperature, amount consumed, and overall acceptance of the TMT concept. Ratings and comments pertaining to these factors were collected through a questionnaire. All meals were heated by hot water submersion in pans of water on M2 burners by appointed food service personnel. Each test subject opened the TMT's with a plastic knife provided in a dining packet. A complete description of this field test can be found in Natick Tech Report titled "Field Evaluation of Thermostabilized Meal Trays".[15]

VIII. Packaging and Assembly

Packing of Assembled Meals: Ten meal trays of the same menu were packed, in two rows of five, in a snug fitting fiberboard container with approximate inside dimensions of 18 inches in length, 11-1/4 inches in

width and 8 inches in depth. The inside of each shipping container was fitted with an open box liner (Figure C-1 of Appendix C).

Packing of Meal Components: When assembly of meal components into the outer serving tray is not required by the user agency, thirty-six starch, vegetable or dessert components (7.5 oz.) were packed in a snug fitting fiberboard container with approximate inside dimensions of 15-3/4 inches in length, 10 inches in width, and 6-3/8 inches in depth. The components were packed in 4 layers with 9 components per layer as shown in Figure C-2 of Appendix C. Thirty six entree components (11 oz.) of the same product were packed in a snug fitting fiberboard container with approximate inside dimensions of 13-3/8 inches in length, 12-3/8 inches in width, and 8-3/4 inches in depth. The entree components were packed in six layers with six entrees per layer as shown in Figure C-3 of Appendix C. Pads were fitted between layers and in the top and bottom of the inside of box.

RESULTS AND DISCUSSION

Survey of AF User Groups:

The intended feeding scenarios and the types of meals, menus and heating capabilities required in these scenarios were identified by surveying the potential users suggested in the AF Statement of Need. The TMT was targeted for use by missile maintenance crews and security guards who currently receive box lunches or take-out hot foods from the dining facility.

The results of the survey showed that both users have access to microwave ovens or fabric ration heaters. Rail Garrison crews indicated a need for a shelf stable ration to supplement frozen foods currently stored and served on rail cars. The rail cars have very limited freezer space and may not be readily resupplied with frozen foods during emergency situations. Some rail car kitchens are equipped with microwave ovens and all have the capability to heat rations by hot water submersion.

Missile maintenance and weapon storage crews consist of fewer than 10 people and are resupplied every one to five days. Rail garrison crews normally number 15 to 25 people and on regular missions are also resupplied every one to five days. In November of 1990, NASA expressed interest in the TMT for possible inclusion in the future Space Station, where astronauts will be contained for a period of 90 days and will have access to microwave ovens.

Literature Search:

The literature search revealed many technological advances were being made in the area of high barrier polymeric trays. Semirigid trays are being thermoformed into rectangular, round and compartmented shapes of various sizes from multilayer coextruded sheets of polymeric materials. The most common coextrusions are constructed of polypropylene inner and outer layers adhered to a high barrier polymeric middle layer. The barrier material most commonly used is EVOH or PVDC, or a combination of both. The function of the barrier layer is to inhibit the transmission of oxygen and water vapor through the tray, thereby extending the product shelf life. Most commercially available trays of this type provide retorted products with an 18 month to two year shelf life. Regrind layers composed of scrap polymer and barrier polymer are often included as layers in the coextrusion in an effort to utilize the waste materials remaining after thermoforming.

Polymeric trays are being used for frozen, retorted and aseptically processed foods mainly to provide them with the microwave advantage. Lid structures most commonly used with these trays are tri-laminate materials composed of PP, aluminum foil and polyester films which are heat sealed directly to the tray flange. Plastic bowls are also being manufactured with double-seamed metal pull-top lids. Industry has promptly responded to consumer demands for high quality products with easy-open and microwave convenience.

Market Survey:

A wide variety of semirigid retortable trays and lidstock materials were obtained from the manufacturers listed in Table 10. Technical data provided with samples revealed that, with the exception of Mullinex, all trays were constructed of similar polymers (PP/EVOH or PVDC/PP), had retort capability, and provided an 18 month to 2 year product shelf life. Mullinex trays were constructed of crystalline polyethylene terephthalate (CPET) which is often used to package frozen foods because it offers dual ovenability but not a lengthy shelf life. Round trays, such as those manufactured by James River Corporation, do not provide the cubic density that rectangular trays do. American National Can and DRG rectangular trays were nearly identical in composition except for the tie (adhesive) layers. Lidstock samples were tri-laminates of either PY/foil/PP or PY/PVDC/PP. Commercial samples which showed the most potential for meeting user needs were subjected to performance tests.

Table 10. Commercial Manufacturers

Tray Manufacturers	Lidstock Manufacturers
American National Can	Reynolds
Ball Plastic	Ludlow
DRG Plastics (formerly Hercules)	Archer
Owens/Illinois	
James River Corporation	
Mullinex Packages, Inc.	
Rampart Packaging, Inc.	

Test Protocol:

I. <u>Performance Testing of Lidding Materials</u>

All lidding materials tested withstood retorting. Results of the lidding materials' ability to survive vibration and drop, immediate tray abuse and internal pressure tests are recorded in Table 11. Percent failure was calculated based on the number of trays surviving the previous test. The type of failure, seal or material, is reported in Table 12 and seal strength results after rough handling are reported in Table 13.

Table 11. Lid Structure Testing

Lid Structure	Vibration/ Drop, %	Immediate Tray Abuse, %	Internal Pressure, %	Total % Failure
Retort Pouch	1.4	8.6	0.0	9.7
Ludlow (clear)	30.6	43.1	10.0	63.9
Ludlow (opaque)	13.9	14.8	8.0	31.9
Reynolds (peelable)	100.0	——[a]	——	100.0
Reynolds (break & peel)	41.7	63.5	36.8	83.3

[a] No additional tests conducted due to total failure

Table 12. Failure Types

Lid Structure	Vibration/Drop T[a]	S[b]	M[c]	Immed. Cont. Abuse T	S	M	Internal Burst T	S	M
Retort Pouch	1	1	--	6	--	6	--	--	--
Ludlow (clear)	22	22	--	21	21	--	3	3	--
Ludlow (opaque)	10	8	2	9	7	2	4	--	4
Reynolds (peel)	72	--	72	--	--	--	--	--	--
Reynolds (break & peel)	30	--	30	23	--	23	7	--	7

[a] T = total number of failures
[b] S = number of seal failures
[c] M = number of material failures

Table 13. Seal Strengths of Lidding Material

Lid Structure	Seal Strength, lb/in
Retort Pouch Material	24.10
Ludlow (clear)	11.97
Ludlow (opaque)	13.42
Reynolds (peelable)	———
Reynolds (break & peel)	11.70

Based upon the results of rough handling, immediate tray abuse and internal pressure tests, the retort pouch material clearly out-performed the other lidding materials tested. The seal strength values for both of the non-foil materials (Ludlow) were similar to that for the Reynolds "break and peel" material. However, by classifying the failures into two categories, namely seal failures or lid material failures (including pin holes and flex cracks), the results indicate that seal strength alone cannot be used to predict rough handling performance. For example, most of the Ludlow material failures occurred at the seal, while all of the Reynold's peelable and "break and peel" lids failed due to flex cracks in the material.

II. Performance Testing of Coextruded Polymeric Trays

Results of abuse and seal strength testing on retortable, coextruded polymeric trays are reported in Table 14. No trays failed immediate tray abuse or internal pressure tests.

Table 14. Tray Abuse and Seal Strength

Tray	Vibration/Drop % Failure		Seal Strength, lb/in	
	70°F	-20°F	Initial	After Rough Handling
DRG (Hercules)	0	47.2	29.5	29.2
Owens (rect)	0	94.4	17.4	15.6
Owens (square)[a]	0	27.8	9.7	9.1
Rampart	0	0	20.4	20.7

[a] This tray has a beaded flange. Reported seal strength value represents force required to break the seal up to the ridge. A force greater than 16.8 lb/in was required to break the remainder of the seal.

All of the coextruded trays passed vibration/drop testing at 70°F with zero percent failure. However, a wide range of performance during rough handling after storage at -20°F was found. Failure rates ranged from zero to almost 95 percent. Subsequent testing at ambient temperatures for individual tray abuse and the internal pressure test revealed no failures for any of the trays.

Poor rough handling performance at -20°F appeared to be related to flange width. The Owens rectangular tray had the highest failure rate (94.4%) and the widest flange (1/2 inch). The Rampart tray had the narrowest flange (1/16 inch) and zero percent failure. The other two trays fell between the extremes. It is not known exactly as to why this failure occurred more readily in trays with wide flanges. However, since this failure was seen repeatedly, trays with a flange width of 1/2 inch (Owens) were discontinued from further testing.

The seal strengths of the DRG, Rampart and Owens rectangular trays were well above the minimum required to assure compatibility with retort

processing. Unusual seal strength results were obtained with the Owens square tray due to the raised bead along the flange. The average initial seal strength was low (9.7 lb/in) for that portion of the seal between the interior of the tray and the bead but it was sufficiently high for the remainder of the seal from the bead to the outside edge of the flange. However, the consistently low initial seal strengths did reveal a weakness in the hermetic seal. For this reason, the Owens square trays were withdrawn from further testing. The DRG and Rampart trays demonstrated the best performance and were used in subsequent tests and in final prototype assemblies.

The DRG and Rampart trays were then subjected to burst strength tests. The DRG 10.5 ounce trays burst on the average at 17.6 psig as a result of lid material failure. The Rampart 8.0 ounce trays burst at 18.0 as a result of closure seal failure. The burst strengths recorded are an average taken from all of the sample trays tested. Although the lids (MRE retort pouch material) on DRG 10.5 oz trays failed at 17.6 psig, the lids and trays withstood the retort process. Approximately 87% of the ruptures on the Rampart 8.0 ounce trays were a result of closure seal failures; specifically the lid separated from the tray before the material itself failed. This was due to the narrow width of the flange on the 8.0 ounce tray. However, the average burst strength recorded (18.0 psi) is sufficient enough to ensure trays will withstand the contraction and expansion encountered during the retort cycle. The burst strengths recorded for both trays surpass the FDA requirement of a burst strength of no less than five psig for all retortable polymeric trays.

III. Post Retort / Sterility Testing

A series of heat penetration tests were performed on each product to establish a time/temperature profile and retort process that sufficiently ensures commercial sterilization in a specified container. Strict control of retort over-pressure was essential to achieve seal and tray integrity. Retort over pressure was maintained for all products at 33 ± 1 psig during the sterilization process. This pressure was appropriate for the selected product fill weights in these tests. Product density was also considered in selection of fill weights to optimize the various sized tray's performance and to establish the correct pressure profiles during sterilization. Entrees were processed in DRG rectangular trays with a practical capacity of 11.5 ounces, and all other products were processed in Rampart 8.0 ounce rectangular trays. The retort process requirements are recorded in Table 15.

After retorting, all trays were visually inspected for defects, such as punctured, delaminated or damaged trays and/or lids. Any trays with questionable seals were removed and tested for leakage, however no leaks were detected.

Post-retort tests for residual gas volume were conducted on each TMT product. One sample per retort rack was selected and tested for air content. Only trays with $<10\ cm^3$ residual gas were acceptable. Several products did not meet the residual gas requirements and fill weights were adjusted accordingly. These adjustments were also recorded in Table 15.

Table 15 Retort Process Requirements

Product	Total Fill weight, oz	Vacuum in Hg	Retort Temp °F	Calculated Process (cook time), min[a]
Applesauce	8.4	15	230	7 min (T_I=195°F)
Sliced Peaches	8.7	24	230	"
Sliced Pears	8.4	24	230	"
Fruit Mix	8.0	24	220	"
Apple Dessert	8.4	15	230	"
Chocolate Pudding	8.4	23	250	30
Potato au Gratin	8.2	24	250	25
Rice in Butter Sauce	8.2	24	250	23
Chicken Stew	11.7	22	250	31
Chili con Carne	11.5	20	250	30
Diced Ham with Scalloped Potatoes	11.7	23	250	32
Ham Slices	11.8	23	250	21
Pork BBQ Sauce	11.3	22	250	34
Tuna w/ Noodles	11.7	22	250	27
Corned Beef Hash	11.7	22	250	31
Ham Omelet	11.7	19	250	33
Breakfast Bake w/ Sausage	11.7	19	250	32
Western Omelet	11.7	19	250	33
Potatoes in Butter	8.3	22	250	21
Hominy Grits	8.2	19	250	22
Corn	8.1	23	250	12
Green Beans	8.2	21	250	9
Carrots	8.1	16	250	10
Peas	8.2	16	250	12
Chicken ala King	11.5	24	250	42
Beef Stew	11.5	24	250	38
Beef Strips w/ Green Peppers and Gravy	11.5	24	250	40
Spaghetti w/ Meat Sauce	11.5	24	250	42
Macaroni w/ Cheese	8.0	24	240	45
Chicken Breast in Gravy	11.0	24	240	47
Hamburger Patties	11.0	24	240	32

[a] Calculated process time began after retort reached process temperature.

Retorted trays were tested for burst strengths. In accordance with USDA test methods, one sample per retort cage was selected after processing for testing. Individual trays were submerged under water and

held in place while air was introduced at 10 psig and held for 60 seconds. All trays burst at greater than 10 pounds per square inch.

Retorted products were tested for commercial sterility. In accordance with FSIS standards, six trays were selected per retort load. Samples were incubated at 95 + 5^{o}F for 10 days at which time they were inspected for evidence of spoilage. Microbiological test results verified that all products were commercially sterile (Appendix B).

IV. Methods of Heating

TMT's were subjected to various methods of heating including a microwave oven, hot water submersion and a fabric ration heater. TMT trays were constructed of microwaveable materials, but the lidstock contained a non-microwaveable layer of foil. Therefore, lids were cut off the three tray components of a complete meal with a plastic knife. A small area of lidding material remained around the rim of each tray along the heat seal. The three components were placed simultaneously in a microwave oven (in this case the dessert component was heatable, i.e. apple dessert). The microwave oven did not have a turntable. Cook times ranging from 2 to 10 minutes were applied to determine the optimal heating time for this meal. Different meal combinations, consisting of three or two components (depending on a heatable dessert item), were also tested to obtain the optimal, average cook time. Products were stirred after heating to disperse any hot or cold spots. On the average for all three component meals the optimal cook time in the microwave oven was determined to be 4 minutes. For meals with only two components that

required heating, the average cook time was approximately 3-1/2 minutes. The serving temperature of each component after microwave heating ranged from 110 to 135°F. The small amount of foil lidding material remaining on the trays did not cause arcing in the microwave.

TMT components were also heated by hot water submersion. A 15 gallon steam kettle 2/3 full of water was brought to a simmer (approximately 120°F) before components were placed in it. Up to 15 components could be completely submerged in water in this steam kettle. The number of components which could be heated at one time was unlimited as long as water covered trays completely to ensure uniform heating. It took approximately 20 minutes for products to reach 110-140°F. It was noted that water should not be allowed to boil rapidly, as this tended to overcook the products, and large bubbles caused trays to rise to the surface of the water resulting in non-uniform heating. This method of heating also required waterproof labeling or identification of tray contents, and tools, such as tongs, to remove hot trays without puncturing them. In this experiment, a waterproof marker was used to identify products and tongs and neoprene gloves were used to remove hot trays.

TMT components were also heated in a prototype of the fabric ration heater. Hermetically sealed trays of both 8.0 and 11.5 ounce components were inserted onto the three shelves (two 8.0 oz and one 11.5 oz component per shelf). This was the slowest method of heating the TMT's. It took approximately 50 minutes to 1 hour to bring products up to serving temperature. The need for servicing Combat Vehicle Crews with the TMT at that time had not been established. However, the Food Equipment Systems

Division (FESD) at Natick could, if required, modify the design of the fabric ration heater to more efficiently heat three TMT meals at a time.

V. Producibility Testing

Wornick Producibility Contract:

The first producibility contract, awarded to Wornick Services, Inc. was completed in January 1988. Wornick was responsible for examining TMT's for visual defects, fill and drained weights, residual air, burst strengths and commercial sterility. Results of these tests were concurrent with Natick's previous evaluations of in-house produced TMT's.

Wornick suggested that fill weights on products in both 8.0 ounce (Rampart) and 10.5 ounce (DRG) trays should be increased slightly to reduce the amount of headspace and the stress on the lid and seal area during retorting. This would also reduce the amount of residual air remaining in the trays. Wornick also noted that most products had to be sealed under no less than 24 inches of vacuum to meet residual air requirements of $<10\ cm^3$ per tray. To prevent "flashing" or boiling over of very hot product onto seal areas, products had to be rapidly cooled to $140^{o}F$ before successful seals were obtained. Drained weights, salt and fat content of each TMT product were analyzed and results are recorded in Natick Technical Report No. 88/060 "Production of Retorted Meals in Coextruded Trays." The actual net weights for each product that resulted in trays that met the residual air requirement, and average tray burst strengths, are listed in Table 16. Commercial sterility was verified by incubating samples of each TMT product for 20 days at 95 to $100^{o}F$ before items were shipped to Natick.

Table 16. Wornick TMT Test Results

Product	Adjusted Net Weight, oz	Average Burst Strength, psig
Fruit Mix	8.0	20.5
Peaches	8.0	18.0
Pears	8.1	19.0
Rice in Butter	8.1	22.0
Potatoes au Gratin	8.0	15.0
Chocolate Pudding	8.8	18.5
Spaghetti w/ Meat Sauce	11.5	17.0
Beef Stew	11.6	11.5
Chicken ala King	11.5	15.5
Beef Strips w/ GP	11.6	14.0

Food Innovisions Producibility Contract:

The second producibility contract, awarded to Food Innovisions (FI), was completed in August 1989. FI was responsible for examining TMT's for visual defects, fill and net weights, burst strengths, residual air and commercial sterility. General recommendations were made based on their results, which were similar in nature to previous recommendations by Wornick and Natick's findings on in-house produced TMT's.

FI noted that several products required fill weight adjustments to meet residual air requirements. Products had to be sealed on the Genesis Sealing System at a temperature less than 120°F to avoid flange contamination due to product flashing. Unlike products produced by Wornick, which were sealed at 140°F, these products required a longer cooling period due to the variations in fill weights, style of trays, and the Genesis sealing equipment. Burst strengths varied in psig with volume of tray, i.e. five psig of air in an 8.0 ounce round bowl is less abusive than five psig of air in a 10.5 ounce rectangular tray (note: FI used the Genesis 8.0 oz bowls and 11.0 oz trays with handles instead of the DRG and

Rampart rectangular trays used previously in-house and by Wornick. Genesis trays were not tested for performance at Natick). To meet burst strength requirements, FI had to modify their tray sealer with a flat sealing head in order to achieve a welded seal. Retort over pressures maintained at 33 $\pm$ 1 psig during sterilization cycle were appropriate for TMT's produced, while varied fill weights required strict control and attention to over pressure. FI verified commercial sterility by incubating samples at 100^{O}F for 10 days before final TMT's were shipped to Natick.

VI. <u>Product Acceptance / Shelf Life Testing</u>

Upon Natick's receipt of contract produced TMT's, products were evaluated for sensory attributes by consumer and technical panelists. Each product was given a numerical score between 1 and 9 for its appearance, odor, flavor, texture and overall quality (1 dislike extremely, 9 like extremely). A score between 5 to 9 rates the product's attribute as being fair to excellent. A rating below 5 is poor and that attribute of the product is considered to be unacceptable. Consumer panels consisted of 30 to 40 randomly selected, volunteer Natick employees. Technical panels consisted of 15 to 25 food technologists who have expertise in sensory evaluation of foods.

After initial sensory evaluations, TMT products were stored at 80^{O} and 100^{O}F, 55% relative humidity. Products were withdrawn approximately every six months for panel evaluations. When a product was given an unacceptable overall quality rating at two consecutive withdrawals, it was

withdrawn from the storage study and its shelf life at that temperature for that duration was documented. At the time of this report, the storage study is ongoing and will continue until shelf lives are determined for all products. The most recent evaluation of products was by a consumer panel after products were stored for 24 months at 80°F. Data on some products at two years is not yet available. Several products, such as the vegetable items, macaroni with cheese, hamburger patties and chicken breast in gravy, were developed after this storage study began. These products were accepted by panelists during an accelerated storage study. A separate storage study on these products was initiated. Other products, including hominy grits, potatoes in butter and potatoes au gratin, were overprocessed by the contractor and were excluded from the storage study after their initial evaluation. These products were substituted with better quality, in-house produced products for field tests. The average overall quality scores given to date to products by consumer and technical panelists throughout the storage study are recorded in Table 17.

Sensory evaluation data clearly demonstrated a decrease in product quality over time, particularly for products stored at 100°F. At 80°F, the shelf life of only one product, fruit mix, has been established at a maximum of 12 months. This product has a high percentage of sugar (fructose) which causes it to brown quickly during storage. Since fruit mix also demonstrated significant instability at 100°F in less than 6 months, this product was eliminated from the TMT menu. Peaches and pears were also unacceptable at 100°F storage for 12 months due to browning. These two products were reformulated to include more ascorbic acid, which has been proven to inhibit browning in accelerated

storage tests, and are presently being retested in a related MRE storage study. Technical panelists gave an unacceptable rating to chocolate pudding after 18 months at 80°F (4.5) based on a "soapy" flavor and mouthfeel, however consumer panelists have continued to rate it acceptable after 18 months (5.9) and 24 months (5.7). The maximum shelf life of a product will not be determined until both technical and consumer panelists rate it unacceptable after the same length of time in storage.

Table 17 Consumer and Technical Panel Ratings[a]

	CONSUMER PANEL									TECHNICAL PANEL						
	I		6M		12M		18M		24M	I		6M		12M		18M
Product	80	100[b]	80	100	80	100	80	100	80	80	100	80	100	80	100	80
Applesauce	7.0	6.7	6.0	5.0	6.1	5.1				6.3	6.3	6.4	6.0	5.9	4.6	
Peaches	7.3	7.0		4.9	7.0	4.9	6.8		6.4	6.5	6.8			5.7	1.5	5.5
Pears	7.2	7.0		5.7	7.5		7.1		6.5	6.2	6.3			5.2	1.9	5.4
Apple Dessert	6.2	6.0	6.4	6.1	6.7	6.3				6.6	6.7	6.5	6.2	6.7	5.4	
Choco Pudding	7.3	7.3		5.8	6.8		5.9		5.7	6.1	6.5			5.1	4.6	4.5
Rice in Butter	6.3	5.9		7.0	5.5	5.3	6.1	5.6	6.5	6.6	6.7			6.2	5.8	6.2
Chicken Stew	6.5	6.8	6.4	6.2	6.3	6.0				6.1	6.1	6.4	5.9	6.3	5.5	
Chili con Carne	6.7	6.7	6.9	6.5	6.4	6.3				6.8	6.5	6.8	6.2	6.6	6.1	
Diced Ham SP	6.2	6.1	5.9	5.3	5.9	5.5				6.2	6.5	6.1	5.5	6.4	5.5	
Ham Slices	6.5	6.2	6.2	6.3	7.1	6.5				6.8	6.6	6.5	6.3	6.6	5.9	
Pork BBQ Sauce	7.0	6.9	6.9	6.6	6.8	6.4				6.8	6.8	6.6	6.5	6.3	6.2	
Tuna w/ Noodles	5.7	5.7	6.0	5.3	5.7	5.1				5.4	5.6	5.7	5.4	5.2	4.8	
Corn Beef Hash	6.3	6.2		5.3	5.4	4.6	5.0	5.5		6.5	6.4					
Ham Omelet	6.2	6.2		5.9	5.8	5.1	6.5	5.5		6.6	6.6					
Breakfast Bake	6.0	6.0			5.8	5.3				6.0	5.8					
Western Omelet	5.8	5.8			5.7	5.1				5.8	5.8					
Fruit Mix	7.3	7.0		4.8	6.2	4.7	6.0		6.1	6.0	6.0			4.4	1.2	4.2
Beef Strips GP	5.9	5.8		5.6	6.4	6.2	6.0	5.4	6.1	6.3	6.1			6.1	5.8	5.5
Spag. w/ Meat	7.0	7.2		6.9	6.7	6.3	6.4	6.0	6.7	6.6	6.6			6.1	6.4	6.2
Beef Stew	7.0	7.0		6.8	6.5	5.5	7.2	6.5	6.8	7.0	6.5			6.6	6.1	6.4
Chix ala King	6.2	6.2		5.8	7.2	6.8	7.1		6.6	6.9	6.7			6.3	4.6	6.0

[a] Numerical ratings are average scores for overall quality
[b] 80 and 100°F temperature of storage rooms

Fifteen complete meals were analyzed for nutritional composition. Overall, the meals provided the military recommended dietary allowances (MRDA) established by the OTSG, however, some meals were low in calcium. The TMT is not intended to feed soldiers for more than five days, thus a slight deficit in calcium for this length of time will not pose a health problem. The OTSG has recommended that TMT's be supplemented with bread,

milk, fresh fruit and fortified beverage bases whenever possible. Each complete meal provides an average of 1000 calories without supplements. (Appendix A).

VII. Field Testing

REDLEG CPV Life Support Exercise:

The TMT prototype menus demonstrated at Fort Sill were enthusiastically received. The meals, which were heated by Combat Vehicle Crews in fabric ration heaters, were perceived as being very convenient to heat and eat from. Crew opinion indicated that this heating system performed flawlessly. The device was able to simultaneously heat three TMT's, one meal per shelf, from 70°F to 165°F in approximately 50 minutes. Crew members had no difficulties in opening the food components with the plastic knife provided. The quality of the meal components was highly rated.[13]

Microwave Field Feeding Technology Demonstration:

Comments obtained on the TMT from troops on site during the demonstration were quite positive. Advantages cited included easy preparation and convenience, specifically that troops working 12 hour shifts would otherwise have missed hot meals if the microwave system were not available. The troops liked the quality of both the TMT and commercial microwave meals so well that they did not consume the MRE, which was provided as their third meal for the day. Comments on the tray durability indicate that the two commercial trays provided (Top Shelf and Impromptu) were subject to damage in the field. However, no reports of

damage to the TMT trays were received. Comments indicate no problems wereencountered while opening the hot TMT's with the plastic knives provided. Some troops were observed opening the trays with their field knives. Commercial microwave meals had peelable lids. Troops saved meal components for heating later in-between meals. MI troops were scattered in the field and were not available for interviewing. However, they indicated positive feedback at the meal distribution point. Troop commanders of the 7^{th} Infantry Units (Light) said they were extremely interested in the individual TMT meals for use in feeding small squads in lieu of Tray Pack meals to reduce food waste.

Holloman AFB User Test:

The crew filled out a one page survey within an hour after returning from the field. Twenty-six people filled out the questionnaire which surveyed opinions on the TMT quality, variety, quantity, ease of preparation and overall acceptance. Survey questions were rated on a 7 point scale (1=dislike very much, 7=like very much). General comments on the TMT suggested products had lack of flavor and were difficult to open. Results of the survey indicate that crew members only liked the TMT's slightly (i.e. ratings only slightly >3.5). Crew members were comparing a very limited variety of TMT's to commercial frozen dinners. Although it was recognized that the comparison of processed, shelf stable foods to frozen foods was not consistent with the proposal that the TMT be tested as a contingency ration, the test was conducted to obtain other data on the TMT when served in this scenario. Table 18 lists the numerical ratings given to the survey questions.

Table 18. Holloman AFB TMT Survey

Survey Question	Mean	Standard Deviation
Food Quality	3.73	1.76
Food Variety	4.50	1.45
Food Quantity	4.81	1.63
Ease of Preparation	4.12	1.63
Overall	3.73	1.71

Rockwell International User Test:

On a scale from very dissatisfied (1) to very satisfied (7) the TMT received an overall neutral rating of 3.4. TMT starches in particular rated low. It should be noted that the number of participants rating the TMT's in each of the three 48 hour tests varied between two and 36, which makes the statistical significance of the resulting data questionable. Also, as in the Holloman test, TMT's were compared to frozen foods. However, the test did provide an opportunity for other potential users to comment on the TMT concept overall when used in a scenario different from that at Holloman. On the average, users rated TMT products higher than the other shelf stable items (MRE) served during the tests.

Barksdale AFB Field Test:

Fifty-five trainees at the Warrior Training Center tested the ten new or reformulated TMT meals at a semi-remote location, in addition to other shelf stable meals, during their week long readiness training program. Approximately 35 meal components could be heated at a time in pans of water on M2 burners. Components were easily heated to serving temperatures (110^{o} - 140^{o}F) within 15 to 20 minutes and assembled into complete meals in the outer compartmented serving trays.

Each product was rated on a 9 point scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely) in accordance with BSD testing procedures. All products were well accepted by test subjects, the average rating being a 7.2. Chicken breast in gravy rated the highest (8.22) and Buttered Potatoes the lowest (5.80). All products were rated acceptable. Product ratings are listed in Table 19.

Table 19. Barksdale AFB Product Ratings

Product	Mean	Std. Dev.	Number Responding
Hamburger Patties	7.03	1.73	36
Chili con Carne	7.15	1.56	27
Chicken ala King	7.86	1.18	28
Ham Slices	7.21	1.59	29
Diced Ham and Potato	6.37	1.98	19
Ham Omelet	5.93	1.79	29
Chicken Breast in Gravy	8.22	0.83	60
Beef Stew	7.69	1.30	62
Spaghetti w/ Meat Sauce	7.95	0.97	39
Tuna w/ Noodles	7.33	1.62	21
Macaroni and Cheese	7.10	1.61	61
Rice in Butter Sauce	6.56	1.71	43
Buttered Potatoes	5.80	2.18	41
Hominy Grits	6.38	2.29	13
Corn	7.60	1.47	48
Green Beans	6.76	2.19	62
Applesauce	6.13	1.46	15
Sliced Peaches	7.38	1.80	37
Sliced Pears	7.03	2.44	33
Apple Dessert	7.59	1.59	61
Chocolate Pudding	7.37	1.42	67

At the end of the field test, trainees were asked to fill out a questionnaire on ease of preparation, ease of opening, serving temperature, amount consumed and the overall acceptability. Results of the questionnaire are recorded in Natick Technical Report "Field Evaluation of the TMT", referenced previously.

VIII. Packaging and Assembly

The shipping containers for TMT's were designed to accommodate the needs of the potential users. For example, TMT's may be packed fully assembled into outer serving trays, or components of the TMT's may be packed separately for users who may not require assembled meals or for contract assemblers who will assemble TMT meals for the Air Force.

Assembled TMT's are available in shipping containers packed in units of ten identical meals. Individual components (entrees, starch/vegetables, desserts) are available in shipping containers packed with 36 trays of the same item. Specific shipping container designs and arrangement of contents are described and shown in detail in the TMT Packaging and Assembly specification document (Appendix C). The specification requires shipping containers to be constructed of various types of fiberboard, depending on the level of pack required by the user. The level of pack is dependent upon the area where TMT's are to be consumed, transported to or stored.

CONCLUSIONS

The TMT was designed to be a shelf stable meal, providing an individual with breakfast, lunch and dinner for a limited number of days, and is capable of being heated in a microwave oven, hot water submersion or in an induction type fabric heater. A complete meal consists of an entree, starch or vegetable, and dessert components which may be assembled into an outer compartmented serving tray.

Based on results of performance tests, the lidding material for retortable trays shall be constructed from outside to inside of .0005" polyester, .00035-.0007" aluminum foil, and .0035-.004" polypropylene. Semirigid retortable trays shall be constructed from a coextrusion of structural polypropylene, regrind, adhesive, PVDC or EVOH, adhesive, regrind, structural polypropylene polymers in the dimensions specified in the TMT Packaging and Assembly specification (Appendix C).

Lidding material heat-sealed to the 8.0 ounce trays at 350°F with 40 psig and a 2 second dwell provides sufficient seal strength to withstand the retort process. Lidding material heat-sealed to 11.0 ounce trays at 350°F with 60 psig and a 1 second dwell is adequate. Trays must be sealed with a minimum of 24" vacuum to meet residual air requirement of <10 cm^3 per tray.

Based on results of post-retort sterility tests, retort processes established for each TMT product are accurate and acceptable, providing overriding pressure is carefully maintained to ensure tray integrity. Separate specifications have been written for TMT Beef Products, Breakfast

Items, Chicken Products, Dessert Products, Pasta Products, Pork and Ham Products, and Vegetable Products.

Based on post-retort and shelf life examinations, testing requirements were written for residual gas volume, seal strength, leakage, sterility, oxygen and water vapor transmission rates. Testing requirements were also written for tray and lid material composition. TMT products and packaging materials must meet these requirements to ensure their integrity throughout processing, shipping, handling and storage. Requirements are outlined in the methods of inspection section of the TMT Packaging and Assembly Specification (Appendix C).

A five day menu consists of products rated acceptable by consumer and technical panelists during the long term storage study, and products rated acceptable by field test subjects when compared with other shelf stable foods. Fifteen different meals, five each of breakfast, lunch and dinner, make up the five day menu cycle. The shelf life of the TMT is currently being established, but preliminary storage study data indicates a shelf life greater than two years is attainable. When supplemented with fortified beverage bases, the TMT is a nutritionally complete meal and meets OTSG requirements for MRDA (Appendix A).

The limited field demonstrations at Fort Sill and Fort Hunter Liggett demonstrated the variety of methods with which the TMT may be heated. The Combat Vehicle Crews were successfully able to heat the TMT's with fabric ration heaters, and troops from the 7th Infantry Division were enthusiastically receptive to the convenient, microwaveable TMT's which they prepared during the Microwave Field Feeding Technology Demonstration.

The limited user tests at Holloman AFB and RI identified important potential users of the TMT in different scenarios. As a result of these tests, the outer serving tray was made an optional feature since Rail Garrison Crews demonstrated that it may not be needed in all situations. The limited tests also demonstrated that when compared to other shelf stable foods, TMT's were most often preferred. The full scale field test at Barksdale AFB significantly demonstrated a high acceptance of the TMT by AF personnel in semi-remote locations. The test subjects liked the convenience and utility of the outer trays and saved them to use with other shelf stable rations provided at other times. This test also demonstrated the feasibility of heating large quantities of TMT's by hot water submersion. Comments regarding the food quality and acceptability were extremely favorable.

The TMT will adequately service personnel in remote locations. It meets the nutritional requirements established by the OTSG when provided for 1-5 days, and offers sufficient menu variety. The meal tray is shelf stable for a minimum of two years and is presented in a familiar tray configuration. It may be heated by microwave, hot water submersion, or with a fabric ration heater. The TMT is producible by industry in large quantities and has been successfully field tested by Air Force personnel. Specifications have been prepared to include all product and packaging requirements necessary for the production of TMT's.

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-91/043 in the series of reports approved for publication.

REFERENCES

1 Gigliotti, M. F. 1990. Worldwide Trends Restructuring The Food Packaging Business. Proceedings of FOODPLAS VII -'90 Conference, Plastics Institute of America, Inc., New Jersey.

2 Kelley, N. and Jones, J. 1986. Performance Testing of Lidding Structures for Semirigid Containers, Memorandum Report No. 155, SPB, Food Engineering Directorate, Natick.

3 ASTM Committee D-10 on Packaging, 1981. Vibration Testing of Shipping Containers, ASTM, Philadelphia, PA.

4 ASTM Committee D-10 on Packaging, 1980. Drop Test for Loaded Boxes, ASTM, Philadelphia, PA.

5 ASTM Committee D-10 on Packaging, 1985. Seal Strength of Flexible Barrier Materials, ASTM, Philadelphia, PA.

6 Kelley, N. and Jones, J. 1986. Performance Testing of Retortable Coextruded Polymeric Containers, Memorandum Report No. 160, SPB, Food Engineering Directorate, Natick.

7 Oleksyk, L. and Jones, J. 1990. Burst Strength Testing of Semirigid Polymeric Containers, Memorandum Report No. 175, SPB, Food Engineering Directorate, Natick.

8 Shappee, J. and Werkowski, S. 1972. A Study of a Nondestructive Test for Determining the Volume of Air in Flexible Food Packages, Natick TR-74-8-096.

9 ASTM Committee F-2 on Flexible Barrier Materials, 1984. Standard Test Method for Leaks in Heat Sealed Flexible Packages, ASTM, Philadelphia, PA.

10 Late, K. G. 1988. Production of Retorted Meals in Coextruded Barrier Trays, Wornick Services, Inc., Natick TR-88/060, Natick.

11 Hogy, B. E. 1989. Production of Foods in Retortable Barrier Polymeric Containers, Food Innovisions, Inc., Harahan, LA.

12 Darsch, G. 1986. REDLEG: Physiological and Psychological Effects of Nuclear, Biological, and Chemical and Extended Operations on Crews (P^2NBC^2) Command Post Vehicle Life Support Exercise, Natick TR-86/049L.

13 Hertweck, G. 1988. Letter Report of the Concept Feasibility Demonstration of a Proposed Microwave Field Feeding System, STRNC-WE, FESD, Food Engineering Directorate, Natick.

14 Oleksyk, L. 1990. Product Assessment Review Summary (PARS), SPB, Food Engineering Directorate, Natick.

15 Behavioral Science Division, 1991. Field Evaluation of TMT Ration, Soldier Science Directorate, Natick TR (DRAFT), Natick.

APPENDIXES

APPENDIX A

NUTRITIONAL ANALYSIS
OF
TMT MEALS

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED 09/11/90

MEAL 1 BREAK	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
POT W/ BACON	203.23	17.98	13.78	5.15	54	313	1.99	1301	1009	57	2.80	2.98	36
APPLESAUCE	187.96	.34	.11		6	15	.26	4	159	19			0
PEACHES SLIC	172.65	1.04	.28	.36	9	21	.70	26	202	13	.02	.00	
COCOA BEV PD	.56	1.42	3.51	1.00	34	99	.41	107	246	17	.21		
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	564.42	20.78	17.68	6.64	105	453	3.43	1438	1658	110	3.04	2.98	36

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
POT W/ BACON				3	.21	.21	7.4	.27	30	.30	7.44	57.54	426	298
APPLESAUCE		.610	1020	2	.03	.05	.4	.06	2	.00	.41	24.22	99	213
PEACHES SLIC				21	.02	.02	1.3	.04	9		7.65	38.29	160	213
COCOA BEV PD	1470		1470	24	.66	.06	.1	.57	2	.15	.15	15.01	97	22
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	1470	.610	2490	58	.92	.34	9.6	.94	43	.45	15.66	136.16	787	746

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED

09/11/90

MEAL 2 BREAK	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
OMEL/BACON	185.37	36.41	54.56	5.89	89	592	4.29	2060	563	39	4.35	5.95	458
POT BUT SCE	174.84	3.85	8.67	2.38	66	70	1.17	557	468	28	1.45	2.13	17
PEARS SLICED	171.27	.43	.19	.19	13	15	.66	21	121	13	.06	.00	
COCOA BEV PD	.56	1.42	3.51	1.00	34	99	.41	107	246	17	.21		
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	532.06	42.10	66.94	9.59	204	781	6.60	2746	1439	100	6.07	8.08	475

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
OMEL/BACON	1420	.063	1520		.21	.63	6.5	.24	36	1.49	7.74	15.45	699	298
POT BUT SCE	870	.132	1090	0	.00	.02	2.6	.09	19		.43	22.88	185	213
PEARS SLICED				13	.02	.00	.2	.02	9		2.13	40.55	166	213
COCOA BEV PD	1470		1470	24	.66	.06	.1	.57	2	.15	.15	15.01	97	22
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	3760	.194	4080	44	.89	.71	9.8	.92	66	1.64	10.44	94.98	1151	746

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED

09/11/90

MEAL 3 BREAK	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
CRND BF HASH	217.31	34.14	9.05	6.55	18	313	6.13	1780	1155	63	4.26	8.93	39
HOMINY GRITS	187.17	1.62	7.29	1.57	4	15	.89	648	115	6	1.62	.00	13
APPLESAUCE	187.96	.34	.11		6	15	.26	4	159	19			0
COCOA BEV PD	.56	1.42	3.51	1.00	34	99	.41	107	246	17	.21		
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	593.02	37.52	19.96	9.25	65	446	7.76	2541	1716	109	6.09	8.93	51

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
CRND BF HASH		.074	120	3	.00	.30	8.3	.36	36	1.49	2.98	30.63	341	298
HOMINY GRITS					.06	.06	.1	.02	6		1.06	14.97	132	213
APPLESAUCE		.610	1020	2	.03	.05	.4	.06	2	.00	.41	24.22	99	213
COCOA BEV PD	1470		1470	24	.66	.06	.1	.57	2	.15	.15	15.01	97	22
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	1470	.685	2610	37	.75	.48	9.4	1.01	47	1.64	4.60	85.92	673	746

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED

09/11/90

MEAL 4 BREAK	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
BRDPUD/M/SAU	179.11	21.64	29.44	3.81	128	327	4.29	1527	339	39	2.68	2.98	226
POT BUT SCE	174.84	3.85	8.67	2.38	66	70	1.17	557	468	28	1.45	2.13	17
PEARS SLICED	171.27	.43	.19	.19	13	15	.66	21	121	13	.06	.00	
COCOA BEV PD	.56	1.42	3.51	1.00	34	99	.41	107	246	17	.21		
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	525.81	27.33	41.82	7.51	243	516	6.60	2213	1215	100	4.40	5.10	243

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
BRDPUD/M/SAU	890		890		.24	.54	5.7	.09	27	.30	2.68	63.67	606	298
POT BUT SCE	870	.132	1090	0	.00	.02	2.6	.09	19		.43	22.88	185	213
PEARS SLICED				13	.02	.00	.2	.02	9		2.13	40.55	166	213
COCOA BEV PD	1470		1470	24	.66	.06	.1	.57	2	.15	.15	15.01	97	22
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	3230	.132	3450	44	.92	.62	8.9	.77	57	.45	5.38	143.21	1059	746

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED 09/11/90

MEAL 5 BREAK	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
WEST OMELET	209.95	30.10	32.66	5.75	143	461	4.44	1750	563	45	4.08	2.98	464
HOMINY GRITS	187.17	1.62	7.29	1.57	4	15	.89	648	115	6	1.62	.00	13
PEACHES SLIC	172.65	1.04	.28	.36	9	21	.70	26	202	13	.02	.00	
COCOA BEV PD	.56	1.42	3.51	1.00	34	99	.41	107	246	17	.21		
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	570.36	34.17	43.74	8.81	192	601	6.51	2532	1167	85	5.93	2.98	477

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
WEST OMELET	1050	.063	1150		.24	.60	4.5	.27	101	1.19	12.50	19.23	491	298
HOMINY GRITS					.06	.06	.1	.02	6		1.06	14.97	132	213
PEACHES SLIC				21	.02	.02	1.3	.04	9		7.65	38.29	160	213
COCOA BEV PD	1470		1470	24	.66	.06	.1	.57	2	.15	.15	15.01	97	22
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	2520	.063	2620	53	.99	.74	6.4	.90	118	1.34	21.37	88.60	885	746

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED

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TOTALS	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
LUNCH 1	487.87	45.02	53.09	5.87	121	441	12.64	2406	1538	100	5.76	8.93	80
2	478.52	68.33	52.07	11.14	353	1009	11.66	3030	1228	119	6.28	20.41	233
3	584.38	34.28	11.12	2.76	164	328	5.44	1868	713	93	1.45	2.13	1
4	481.62	55.26	45.77	7.03	88	485	8.56	1939	1375	92	4.51	8.93	98
5	686.75	52.60	37.12	12.70	204	596	9.05	3808	1298	131	7.84	11.77	90
MEAN	543.83	51.10	39.83	7.90	186	572	9.47	2610	1231	107	5.17	10.43	101
MEAL REQUIREMENTS 1/3 AR 40-25		33.33	53.3		267	267	6.0	1667-2334	625-1825	133		5.0	

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
1	640		640	34	.19	.65	11.9	.37	56	1.79	5.49	170.07	1338	762
2	590	.094	750	34	.17	.82	9.9	.48	48	2.08	5.19	151.86	1349	762
3		5.539	9230	47	.28	.36	13.7	.42	66	2.62	2.92	129.38	755	762
4	640	.518	1500	37	.60	.77	11.3	.63	29	.60	6.97	172.24	1322	762
5	1620	6.513	12470	34	.18	.75	11.9	.44	58	.33	7.91	213.72	1399	1003
MEAN	873	3.166	4918	37	.28	.67	11.7	.47	51	1.48	5.70	167.45	1233	810
MEAL REQUIREMENTS 1/3 AR 40-25			1670	20	0.60	0.73	8.0(N.E.)	0.73	133	1.0	3.3	146.7	1200	

PERCENT OF CALORIES FROM: PROTEIN - 17 PERCENT
FAT - 29 PERCENT
CHO - 54 PERCENT

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MEAL 6 LUNCH	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
CHILI	194.59	39.09	40.48	3.10	80	357	7.89	1363	1283	77	3.48	8.93	80
RICE	138.31	5.36	10.72	1.96	26	66	.77	904	94	13	1.96	.00	
APPLE DSRT	154.94	.57	1.89	.51	13	13	3.91	138	121	6	.32	.00	
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	487.87	45.02	53.09	5.87	121	441	12.64	2406	1538	100	5.76	8.93	80

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
CHILI					.06	.48	9.8	.24	39	1.79	3.57	20.42	602	298
RICE	640		640		.11	.13	1.5	.09	9		1.49	56.28	343	213
APPLE DSRT					.02	.04	.2	.04	9		.43	54.71	238	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	640		640	34	.19	.65	11.9	.37	56	1.79	5.49	170.07	1338	762

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED 09/11/90

MEAL 7 LUNCH	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
HAMBURGERS	205.76	52.30	34.14	5.09	36	515	6.10	1506	679	45	3.36	11.91	199
MAC/CHEESE	157.49	12.84	13.76	3.47	296	313	1.53	1125	91	28	2.30	2.13	32
CHOC PUDDING	115.24	3.19	4.17	2.28	19	176	3.95	398	417	43	.62	6.38	2
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	478.52	68.33	52.07	11.14	353	1009	11.66	3030	1228	119	6.28	20.41	233

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
HAMBURGERS					.06	.48	8.0	.42	18	2.08	1.79	.39	518	298
MAC/CHEESE	590	.094	750		.11	.26	1.3	.04	21		.64	25.07	275	213
CHOC PUDDING					.00	.09	.2	.02	9		2.76	87.75	401	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	590	.094	750	34	.17	.82	9.9	.48	48	2.08	5.19	151.86	1349	762

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MEAL 8 LUNCH	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
TUNA&NOODLES	216.71	30.66	10.72		54	268	2.86	1280	330	45			1
GREENBEANS	196.38	3.19	.21	2.25	96	40	1.85	566	221	32	1.38	2.13	
PEARS SLICED	171.27	.43	.19	.19	13	15	.66	21	121	13	.06	.00	
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	584.38	34.28	11.12	2.76	164	328	5.44	1868	713	93	1.45	2.13	1

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
TUNA&NOODLES		5.061	8430	0	.21	.25	12.7	.36	19	2.62	.16	39.59	377	298
GREENBEANS		.478	800		.04	.11	.4	.04	38		.64	10.59	57	213
PEARS SLICED				13	.02	.00	.2	.02	9		2.13	40.55	166	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM		5.539	9230	47	.28	.36	13.7	.42	66	2.62	2.92	129.38	755	762

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MEAL 9 LUNCH	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
PORK BBQ SCE	188.34	49.33	33.16	4.26	48	402	3.81	896	1119	68	2.23	8.93	98
RICE	138.31	5.36	10.72	1.96	26	66	.77	904	94	13	1.96	.00	
APPLE DSRT	154.94	.57	1.89	.51	13	13	3.91	138	121	6	.32	.00	
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0	4	.00		
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41				
SUM	481.62	55.26	45.77	7.03	88	485	8.56	1939	1375	92	4.51	8.93	98

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
PORK BBQ SCE		.518	860	3	.48	.60	9.2	.51	12	.60	5.06	22.59	586	298
RICE	640		640		.11	.13	1.5	.09	9		1.49	56.28	343	213
APPLE DSRT					.02	.04	.2	.04	9		.43	54.71	238	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	640	.518	1500	37	.60	.77	11.3	.63	29	.60	6.97	172.24	1322	762

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MEAL 10 LUNC	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
CHKN ALAKING	236.05	42.22	21.94	6.10	85	306	3.20	1897	492	49	3.94	3.26	88
RICE	138.31	5.36	10.72	1.96	26	66	.77	904	94	13	1.96	.00	
CARROTS SLIC	197.12	1.83	.30	2.06	72	43	1.06	608	255	23	1.32	2.13	
CHOC PUDDING	115.24	3.19	4.17	2.28	19	176	3.95	398	417	43	.62	6.38	2
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	686.75	52.60	37.12	12.70	204	596	9.05	3808	1298	131	7.84	11.77	90

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALCRIES	WEIGHT (G)
CHKN ALAKING	980		980		.03	.49	9.1	.29	26	.33	1.96	19.72	445	326
RICE	640		640		.11	.13	1.5	.09	9		1.49	56.28	343	213
CARROTS SLIC		6.513	10850		.04	.04	.6	.04	15		1.70	11.31	55	213
CHOC PUDDING					.00	.09	.2	.02	9		2.76	87.75	401	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	1620	6.513	12470	34	.18	.75	11.9	44	58	.33	7.91	213.72	1399	1003

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TOTALS		WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
DINNER	1	500.72	33.14	18.45	10.95	176	524	13.11	2828	1761	147	6.06	9.36	41
	2	508.22	63.58	19.06	6.43	117	714	7.24	1986	1629	239	2.85	10.86	106
	3	517.54	40.39	19.80	6.40	120	538	8.16	1817	1602	233	2.58	10.86	53
	4	549.11	47.82	30.67	8.81	372	615	7.69	2500	1165	98	5.33	11.06	100
	5	437.69	38.91	17.24	6.30	88	374	4.09	1776	993	78	3.95	6.17	111
	MEAN	502.66	44.77	21.05	7.78	175	553	8.06	2181	1430	159	4.15	9.66	82
MEAL REQUIREMENTS 1/3 AR 40-25			33.33	53.3		267	267	6.0	1667-2334	625-1825	133		5.0	

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
1		1.189	1980	37	.14	.52	10.0	.50	41	.89	8.85	198.66	1093	762
2				57	.32	.52	26.9	.66	138	.60	5.86	164.63	1084	762
3		2.230	3720	57	.32	.52	14.4	.46	132	.30	6.45	177.79	1051	762
4	590	2.609	4940	55	.22	.58	11.3	.50	51	.89	12.76	125.51	969	762
5	870	.132	1090	47	.29	.31	8.4	.38	40	.27	2.96	102.08	719	599
MEAN	730	1.540	2933	51	.26	.49	14.2	.50	80	.59	7.37	153.73	983	729
MEAL REQUIREMENTS 1/3 AR 40-25			1670	20	0.60	0.73	8.0(N.E.)	0.73	133	1.0	3.3	146.7	1200	

PERCENT OF CALORIES FROM: PROTEIN - 18 PERCENT
FAT - 19 PERCENT
CHO - 63 PERCENT

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED 09/11/90

MEAL 11 DINN	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
SPGH W/MTSAC	221.03	23.49	13.31	6.49	146	262	8.22	1991	967	68	4.38	2.98	39
CORN WK D	164.42	6.46	.98	1.87	9	81	.87	438	336	32	1.06	.00	0
CHOC PUDDING	115.24	3.19	4.17	2.28	19	176	3.95	398	417	43	.62	6.38	2
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	500.72	33.14	18.45	10.95	176	524	13.11	2828	1761	147	6.06	9.36	41

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
SPGH W/MTSAC		.896	1490	3	.12	.33	6.8	.42	18	.89	5.66	33.37	347	298
CORN WK D		.293	490		.02	.11	2.6	.06	15		.43	38.89	190	213
CHOC PUDDING					.00	.09	.2	.02	9		2.76	87.75	401	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM		1.189	1980	37	.14	.52	10.0	.50	41	.89	8.85	198.66	1093	762

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED

MEAL 12 DINN	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
CHIX BR/GRVY	219.24	50.99	14.17	3.84	54	494	1.19	1122	804	63	2.23	2.98	104
GREEN PEAS	173.71	9.40	.72		43	38	2.02	466	368	130		1.50	
CHOC PUDDING	115.24	3.19	4.17	2.28	19	176	3.95	398	417	43	.62	6.38	2
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	508.22	63.58	19.06	6.43	117	714	7.24	1986	1629	239	2.85	10.86	106

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
CHIX BR/GRVY				3	.06	.27	24.7	.51	36	.60	1.19	9.44	369	298
GREEN PEAS				20	.26	.17	1.6	.14	94		1.90	28.79	159	213
CHOC PUDDING					.00	.09	.2	.02	9		2.76	87.75	401	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM				57	.32	.52	26.9	.66	138	.60	5.86	164.63	1084	762

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED

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MEAL 13 DINN	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
CHICKEN STEW	228.56	27.80	14.91	3.81	57	319	2.11	953	777	57	1.96	2.98	51
GREEN PEAS	173.71	9.40	.72		43	38	2.02	466	368	130		1.50	
CHOC PUDDING	115.24	3.19	4.17	2.28	19	176	3.95	398	417	43	.62	6.38	2
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	517.54	40.39	19.80	6.40	120	538	8.16	1817	1602	233	2.58	10.86	53

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
CHICKEN STEW		2.230	3720	3	.06	.27	12.2	.30	30	.30	1.79	22.59	336	298
GREEN PEAS				20	.26	.17	1.6	.14	94		1.90	28.79	159	213
CHOC PUDDING					.00	.09	.2	.02	9		2.76	87.75	401	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM		2.230	3720	57	.32	.52	14.4	.46	132	.30	6.45	177.79	1051	762

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED

09/11/90

MEAL 14 DINN	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
BE F STEW	218.94	33.94	16.64	4.67	65	277	5.39	1348	831	54	3.01	8.93	68
MAC/CHEESE	157.49	12.84	13.76	3.47	296	313	1.53	1125	91	28	2.30	2.13	32
PEACHES SLIC	172.65	1.04	.28	.36	9	21	.70	26	202	13	.02	.00	
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	549.11	47.82	30.67	8.81	372	615	7.69	2500	1165	98	5.33	11.06	100

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
BEEF STEW		2.515	4190		.09	.30	8.3	.42	21	.89	4.47	23.49	379	298
MAC/CHEESE	590	.094	750		.11	.26	1.3	.04	21		.64	25.07	276	213
PEACHES SLIC				21	.02	.02	1.3	.04	9		7.65	38.29	160	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	590	2.609	4940	55	.22	.58	11.3	.50	51	.89	12.76	125.51	969	762

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED 09/11/90

MEAL 15 DINN	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
HAM SLICES	91.56	34.63	8.38	3.42	7	284	2.19	1197	364	34	2.44	4.04	94
POT BUT SCE	174.84	3.85	8.67	2.38	6[illegible]	70	1.17	557	468	28	1.45	2.13	17
PEARS SLICED	171.27	.43	.19	.19	1[illegible]	15	.66	21	121	13	.06	.00	
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	437.69	38.91	17.24	6.30	88	374	4.09	1776	993	78	3.95	6.17	111

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
HAM SLICES					.27	.28	5.3	.27	12	.27	.40	.00	214	135
POT BUT SCE	870	.132	1090	0	.00	.02	2.6	.09	19		.43	22.88	165	213
PEARS SLICED				13	.02	.00	.2	.02	9		2.13	40.55	166	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM	870	.132	1090	47	.29	.31	8.4	.38	40	.27	2.96	102.08	719	599

RECORD OF NUTRITIVE VALUES TMT 5 DAY MENU CYCLE REVISED 09/11/90

MEAL 12 DINN	WATER (G)	PROTEIN (G)	FAT (G)	ASH (G)	CALCIUM (MG)	PHOS (MG)	IRON (MG)	SODIUM (MG)	POTASS (MG)	MAGNESIUM (MG)	NACL (G)	ZINC (MG)	CHOLESTROL (MG)
CHIX BR/GRVY	219.24	50.99	14.17	3.84	54	494	1.19	1122	804	63	2.23	2.98	104
GREEN PEAS	173.71	9.40	.72		43	38	2.02	466	368	130		1.50	
CHOC PUDDING	115.24	3.19	4.17	2.28	19	176	3.95	398	417	43	.62	6.38	2
BEVERAGE BSE	.00	.00	.00	.19	0	0	.00	0	0				
COFFEE INSTA	.03	.00	.00	.12	2	5	.07	1	41	4	.00		
SUM	508.22	63.58	19.06	6.43	117	714	7.24	1986	1629	239	2.85	10.86	106

	A (IU)	CAROTENE (MG)	TOTAL A (IU)	C (MG)	B1 (MG)	B2 (MG)	NIACIN (MG)	B6 (MG)	FOLACIN (MCG)	B12 (MCG)	E (MG)	CHO (G)	CALORIES	WEIGHT (G)
CHIX BR/GRVY				3	.06	.27	24.7	.51	36	.60	1.19	9.44	369	298
GREEN PEAS				20	.26	.17	1.6	.14	94		1.90	28.79	159	213
CHOC PUDDING					.00	.09	.2	.02	9		2.76	87.75	401	213
BEVERAGE BSE				26								37.56	150	38
COFFEE INSTA				8		.00	.4	.00				1.10	4	1
SUM				57	.32	.52	26.9	.66	138	.60	5.86	164.63	1084	762

APPENDIX B

MICROBIOLOGICAL TESTING OF TMT'S
FOR
COMMERCIAL STERILITY

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor :	Ms. L. Oleksyk	**Date:**	May 18, 1990
Account No.:	OMA	**Date Received:**	05/04/90
Package Type :	Thermostabilized Meal Trays	**Report No.:**	44
Processor :	NLABS		

PRODUCT	MAL NO.	STORAGE HISTORY
Green Beans	504	Incubated for 10 days at 30C
Green Beans	505	Incubated for 10 days at 30C
Green Beans	506	Incubated for 10 days at 30C
Corn	510	Incubated for 10 days at 30C
Corn	511	Incubated for 10 days at 30C
Corn	512	Incubated for 10 days at 30C
Tuna Noodle Casserole	516	Incubated for 10 days at 30C
Tuna Noodle Casserole	517	Incubated for 10 days at 30C
Tuna Noodle Casserole	518	Incubated for 10 days at 30C
Hominy Grits	522	Incubated for 10 days at 30C
Hominy Grits	523	Incubated for 10 days at 30C
Hominy Grits	524	Incubated for 10 days at 30C
Rice	527	Incubated for 10 days at 30C
Rice	528	Incubated for 10 days at 30C
Rice	529	Incubated for 10 days at 30C

MAL NO.	OTHER DATA
504	Retorted at 240F; Fo=4.56
505	Retorted at 240F; Fo=4.56
506	Retorted at 240F; Fo=4.56
510	Retorted at 240F; Fo=11.11
511	Retorted at 240F; Fo=11.11
512	Retorted at 240F; Fo=11.11
516	Retorted at 240F; Fo=7.70
517	Retorted at 240F; Fo=7.70
518	Retorted at 240F; Fo=7.70
522	Retorted at 240F; Fo=11.06
523	Retorted at 240F; Fo=11.06
524	Retorted at 240F; Fo=11.06
527	Retorted at 240F; Fo=8.04
528	Retorted at 240F; Fo=8.04
529	Retorted at 240F; Fo=8.04

Microbiology Analytical Laboratory
Microbiology Section
Soldier Science Directorate

RESULTS:

MAL NO.	pH	ODOR/ APPEARANCE	MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
504	5.25	Normal	Negative	<10	<10
505	5.35	Normal	Negative	<10	<10
506	5.42	Normal	Negative	<10	<10
510	6.54	Normal	Negative	<10	<10
511	6.49	Normal	Negative	<10	<10
512	6.58	Normal	Negative	<10	<10
516	5.94	Normal	Negative	<10	<10
517	5.96	Normal	Negative	<10	<10
518	5.99	Normal	Negative	<10	<10
522	5.74	Normal	Negative	<10	<10
523	5.73	Normal	Negative	<10	<10
524	5.72	Normal	Negative	<10	<10
527	6.36	Normal	Negative	<10	<10
528	6.25	Normal	Negative	<10	<10
529	6.37	Normal	Negative	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.
Conducting a storage study of 3 months at 30C.

Claire H Lee
Claire H. Lee

Approved: Gerald Silverman
Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor : Ms. L. Oleksyk

Account No.: OMA

Package Type : Thermostabilized Meal Trays

Processor : NLABS

Date: May 25, 1990

Date Received: 05/10/90

Report No.: 45

PRODUCT	MAL NO.	STORAGE HISTORY
Applesauce	695	Incubated at 30C for 10 days
Applesauce	696	Incubated at 30C for 10 days
Applesauce	697	Incubated at 30C for 10 days
Spaghetti w/ meat sauce	702	Incubated at 30C for 10 days
Spaghetti w/ meat sauce	703	Incubated at 30C for 10 days
Spaghetti w/ meat sauce	704	Incubated at 30C for 10 days
Chili con carne	707	Incubated at 30C for 10 days
Chili con carne	708	Incubated at 30C for 10 days
Chili con carne	709	Incubated at 30C for 10 days
Slice pears	713	Incubated at 30C for 10 days
Slice pears	714	Incubated at 30C for 10 days
Slice pears	715	Incubated at 30C for 10 days

MAL NO.	OTHER DATA
695	Retorted at 220F
696	Retorted at 220F
697	Retorted at 220F
702	Retorted at 240F; Fo=6.99
703	Retorted at 240F; Fo=6.99
704	Retorted at 240F; Fo=6.99
707	Retorted at 240F;Fo=7.58
708	Retorted at 240F;Fo=7.58
709	Retorted at 240F;Fo=7.58
713	Retorted at 220F
714	Retorted at 220F
715	Retorted at 220F

Microbiology Analytical Laboratory
Microbiology Section
Soldier Science Directorate

RESULTS:

MAL NO.	pH	ODOR/ APPEARANCE	MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
695	3.34	Normal	Negative	<10	<10
696	3.33	Normal	Negative	<10	<10
697	3.33	Normal	Negative	<10	<10
702	5.14	Normal	Negative	<10	<10
703	5.23	Normal	Negative	<10	<10
704	5.28	Normal	Negative	<10	<10
707	5.18	Normal	Negative	<10	<10
708	5.19	Normal	Negative	<10	<10
709	5.24	Normal	Negative	<10	<10
713	3.86	Normal	Negative	<10	<10
714	3.81	Normal	Negative	<10	<10
715	3.78	Normal	Negative	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.
Conducting a storage study of 3 months at 30C.

Claire H. Lee

Claire H. Lee

Approved: Gerald Silverman

Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor :	Ms. L. Oleksyk	Date:	June 4, 1990
Account No.:	OMA	Date Received:	05/17/90
Package Type :	Thermostabilized meal trays	Report No.:	50
Processor :	NLABS		

PRODUCT	MAL NO.	STORAGE HISTORY
Beef stew	787	Incubated for 10 days at 30C
Beef stew	788	Incubated for 10 days at 30C
Beef stew	789	Incubated for 10 days at 30C
Corned beef hash	793	Incubated for 10 days at 30C
Corned beef hash	794	Incubated for 10 days at 30C
Corned beef hash	795	Incubated for 10 days at 30C
Beef patties in broth	799	Incubated for 10 days at 30C
Beef patties in broth	800	Incubated for 10 days at 30C
Beef patties in broth	801	Incubated for 10 days at 30C
Potatoes in butter sauce	805	Incubated for 10 days at 30C
Potatoes in butter sauce	806	Incubated for 10 days at 30C
Potatoes in butter sauce	807	Incubated for 10 days at 30C

MAL NO.	OTHER DATA
787	Retorted; Fo=7.46
788	Retorted; Fo=7.46
789	Retorted; Fo=7.46
793	Retorted; Fo=7.91
794	Retorted; Fo=7.91
795	Retorted; Fo=7.91
799	Retorted; Fo=7.27
800	Retorted; Fo=7.27
801	Retorted; Fo=7.27
805	Retorted; Fo=7.66
806	Retorted; Fo=7.66
807	Retorted; Fo=7.66

Microbiology Analytical Laboratory

Microbiology Section

Soldier Science Directorate

RESULTS:

MAL NO.	pH	ODOR/ APPEARANCE	MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
787	5.67	Normal	Negative	<10	<10
788	5.74	Normal	Negative	<10	<10
789	5.73	Normal	Negative	<10	<10
793	5.73	Normal	Negative	<10	<10
794	5.75	Normal	Negative	<10	<10
795	5.73	Normal	Negative	<10	<10
799	6.00	Normal	Negative	<10	<10
800	6.00	Normal	Negative	<10	<10
801	5.99	Normal	Negative	<10	<10
805	5.60	Normal	Negative	<10	<10
806	5.61	Normal	Negative	<10	<10
807	5.52	Normal	Negative	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.
Conducting a storage study of 3 months.

Claire H Lee

Claire H. Lee

Approved: Neil H. McCormick

for Gerald Silverman

Microbi‿.ogy Analytical Labc‿atory

Microbiology Section
Soldier Science Directorate

Requestor : Ms. L. Oleksyk

Account No.: OMA

Package Type : Thermostabilized Meal Trays

Processor : NLABS

Date: June 7, 1990

Date Received: 05/23/90

Report No.: 53

PRODUCT	MAL NO.	STORAGE HISTORY
Chicken Breast in Gravy	811	Incubated for 10 days at 30C
Chicken Breast in Gravy	812	Incubated for 10 days at 30C
Chicken Breast in Gravy	813	Incubated for 10 days at 30C
Chicken ala king	817	Incubated for 10 days at 30C
Chicken ala king	818	Incubated for 10 days at 30C
Chicken ala king	819	Incubated for 10 days at 30C

MAL NO.	OTHER DATA
811	Retorted; Fo=7.92
812	Retorted; Fo=7.92
813	Retorted; Fo=7.92
817	Retorted; Fo=7.52
818	Retcrted; Fo=7.52
819	Retorted; Fo=7.52

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Microbiology Section
Soldier Science Directorate

RESULTS:

MAL NO.	pH	ODOR/ APPEARANCE	MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
811	5.99	Normal	Negative	<10	<10
812	6.05	Normal	Negative	<10	<10
813	6.02	Normal	Negative	<10	<10
817	5.79	Normal	Negative	<10	<10
818	5.94	Normal	Negative	<10	<10
819	6.00	Normal	Negative	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.
A storage study of 3 months is being conducted at 30C.

Claire H Lee
Claire H. Lee

Approved: Gerald Silverman
Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor : Ms. L. Oleksyk

Date: June 15, 1990

Account No.:

Date Received: 06/01/90

Package Type : Thermostabilized meal trays

Report No.: 56

Processor : NLABS

PRODUCT	MAL NO.	STORAGE HISTORY
Apple dessert	841	Incubated for 10 days at 30C
Apple dessert	842	Incubated for 10 days at 30C
Apple dessert	843	Incubated for 10 days at 30C
Macaroni and cheese	847	Incubated for 10 days at 30C
Macaroni and cheese	848	Incubated for 10 days at 30C
Macaroni and cheese	849	Incubated for 10 days at 30C
Peach slices	853	Incubated for 10 days at 30C
Peach slices	854	Incubated for 10 days at 30C
Peach slices	855	Incubated for 10 days at 30C

MAL NO.	OTHER DATA
841	Retorted at 220F
842	Retorted at 220F
843	Retorted at 220F
847	Retorted; Fo=8.00
848	Retorted; Fo=8.00
849	Retorted; Fo=8.00
853	Retorted at 220F
854	Retorted at 220F
855	Retorted at 220F

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Microbiology Section
Soldier Science Directorate

RESULTS:

MAL NO.	pH	ODOR/ APPEARANCE	MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
841	3.92	Normal	Negative	<10	<10
842	3.80	Normal	Negative	<10	<10
843	3.90	Normal	Negative	<10	<10
847	5.70	Normal	Negative	<10	<10
848	5.67	Normal	Negative	<10	<10
849	5.55	Normal	Negative	<10	<10
853	4.22	Normal	Negative	<10	<10
854	4.56	Normal	Negative	<10	<10
855	4.57	Normal	Negative	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.
Conducting a study at 30C for 3 months.

Approved: Gerald Silverman
Gerald Silverman

Claire H Lee
Claire H. Lee

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor :	Ms. L. Oleksyk	Date:	June 22, 1990
Account No.:	OMA	Date Received:	06/05/90
Package Type :	Thermostabilized Meal Trays	Report No.:	60
Processor :	NLABS		

PRODUCT	MAL NO.	STORAGE HISTORY
Chocolate pudding	864	Incubated for 10 days at 30C
Chocolate pudding	865	Incubated for 10 days at 30C
Chocolate pudding	866	Incubated for 10 days at 30C

OTHER DATA

Retorted; Fo=10.38
Retorted; Fo=10.38
Retorted; Fo=10.38

RESULTS:

MAL NO.	pH	ODOR/ APPEARANCE	MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
864	6.19	Normal	Negative	<10	<10
865	5.91	Normal	Negative	<10	<10
866	6.14	Normal	Negative	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.

Claire H. Lee

Approved:
Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

3 MONTHS INCUBATION

Requestor :	Ms. L. Oleksyk	Date:	August 13, 1990
Account No.:	OMA	Date Received:	04/27/90
Package Type :	Thermostabilized Meal Trays	Report No.:	82
Processor :	NLABS		

PRODUCT	MAL NO.	STORAGE HISTORY
Diced Ham w/ Potatoes	474	Incubated for 3 mos. at 30C
Diced Ham w/ Potatoes	475	Incubated for 3 mos. at 30C
Diced Ham w/ Potatoes	476	Incubated for 3 mos. at 30C
Ham Omelot	480	Incubated for 3 mos. at 30C
Ham Omelot	481	Incubated for 3 mos. at 30C
Ham Omelot	482	Incubated for 3 mos. at 30C
Ham Slices	483	Incubated for 3 mos. at 30C
Ham Slices	484	Incubated for 3 mos. at 30C
Ham Slices	485	Incubated for 3 mos. at 30C

RESULTS:

OTHER DATA	MAL NO.	pH	ODOR/ APPEARANCE
Retored at 240F; Fo=>6	474	6.04	Normal
Retored at 240F; Fo=>6	475	6.00	Normal
Retored at 240F; Fo=>6	476	6.06	Normal
Retored at 240F; Fo=>6	480	6.12	Normal
Retored at 240F; Fo=>6	481	6.13	Normal
Retored at 240F; Fo=>6	482	6.14	Normal
Retored at 240F; Fo=>6	483	6.24	Normal
Retored at 240F; Fo=>6	484	6.24	Normal
Retored at 240F; Fo=>6	485	6.30	Normal

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Microbiology Section
Soldier Science Directorate

MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
Negative	<10	<10
Negative	<10	<10
Negative	<10	<10
Negative	<10	<10
Negative	<10	<10
Negative	<10	<10
Negative	<10	<10
Negative	<10	<10
Negative	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.

Claire H Lee
Claire H. Lee

Approved: Gerald Silverman
Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

3 MONTHS

Requestor : Ms. L. Oleksyk

Date: August 17, 1990

Account No.: OMA

Date Received: 05/04/90

Package Type : Thermostabilized Meal Trays

Report No.: 88

Processor : NLABS

PRODUCT	MAL NO.	STORAGE HISTORY
Green Beans	507	Incubated for 3 mos at 30C
Green Beans	508	Incubated for 3 mos. at 30C
Green Beans	509	Incubated for 3 mos. at 30C
Corn	513	Incubated for 3 mos. at 30C
Corn	514	Incubated for 3 mos. at 30C
Corn	515	Incubated for 3 mos. at 30C
Tuna Noodle Casserole	519	Incubated for 3 mos. at 30C
Tuna Noodle Casserole	520	Incubated for 3 mos. at 30C
Tuna Noodle Casserole	521	Incubated for 3 mos. at 30C

RESULTS:

OTHER DATA	MAL NO.	pH	ODOR/ APPEARANCE
Retorted; Fo=4.56	507	5.21	Normal
Retorted; Fo=4.56	508	5.23	Normal
Retorted; Fo=4.56	509	5.26	Normal
Retorted; Fo=11.11	513	6.52	Normal
Retorted; Fo=11.11	514	6.56	Normal
Retorted; Fo=11.11	515	6.55	Normal
Retorted; Fo=7.70	519	5.94	Normal
Retorted; Fo=7.70	520	5.96	Normal
Retorted; Fo=7.70	521	5.95	Normal

Microbiology Analytical Laboratory
Microbiology Section
Soldier Science Directorate

MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.

Claire H Lee
Claire H. Lee

Approved: Gerald Silverman
Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor : Ms. L. Oleksyk

Date: August 17, 1990

Account No.: OMA

Date Received: 05/04/90

Package Type : Thermostabilized Meal Trays

Report No.: 89

Processor : NLABS

PRODUCT	MAL NO.	STORAGE HISTORY
Rice	531	Incubated for 3 mos. at 30C
Rice	532	Incubated for 3 mos. at 30C
Rice	533	Incubated for 3 mos. at 30C
Hominy Grits	525	Incubated for 3 mos. at 30C
Hominy Grits	526	Incubated for 3 mos. at 30C
Hominy Grits	527	Incubated for 3 mos. at 30C
Applesauce	698	Incubated for 3 mos. at 30C
Applesauce	699	Incubated for 3 mos. at 30C
Applesauce	700	Incubated for 3 mos. at 30C
Spaghetti w/ Meat sauce	701	Incubated for 3 mos. at 30C
Spaghetti w/ Meat sauce	705	Incubated for 3 mos. at 30C
Spaghetti w/ Meat sauce	706	Incubated for 3 mos. at 30C

RESULTS:

OTHER DATA	MAL NO.	pH	ODOR/ APPEARANCE
Retorted; Fo=7.85	531	6.16	Normal
Retorted; Fo=7.85	532	6.19	Normal
Retorted; Fo=7.85	533	6.23	Normal
Retorted; Fo=11.06	525	5.51	Normal
Retorted; Fo=11.06	526	5.48	Normal
Retorted; Fo=11.06	527	5.60	Normal
Retorted at 220F	698	3.51	Normal
Retorted at 220F	699	3.50	Normal
Retorted at 220F	700	3.49	Normal
Retorted; Fo=6.99	701	5.10	Normal
Retorted; Fo=6.99	705	5.11	Normal
Retorted; Fo=6.99	706	5.11	Normal

Microbiology Analytical Laboratory
Microbiology Section
Soldier Science Directorate

MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.

Claire H. Lee

Approved: Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor : Ms. L. Oleksyk
Date: August 27, 1990

Account No.: OMA
Date Received: 05/10/90

Package Type : Thermostabilized Meal trays
Report No.: 94

Processor : NLABS

PRODUCT	MAL NO.	STORAGE HISTORY
Chili con carne	710	Incubated for 3 mos. at 30C
Chili con carne	711	Incubated for 3 mos. at 30C
Chili con carne	712	Incubated for 3 mos. at 30C
Sliced pears	716	Incubated for 3 mos. at 30C
Sliced pears	717	Incubated for 3 mos. at 30C
Sliced pears	718	Incubated for 3 mos. at 30C

RESULTS:

OTHER DATA	MAL NO.	pH	ODOR/ APPEARANCE
Retorted at 240F; Fo=6.99	710	5.23	Normal
Retorted at 240F; Fo=6.99	711	5.21	Normal
Retorted at 240F; Fo=6.99	712	5.18	Normal
Retorted at 240F; Fo=7.58	716	3.84	Normal
Retorted at 240F; Fo=7.58	717	3.85	Normal
Retorted at 240F; Fo=7.58	718	3.81	Normal

Microbiology Analytical Laboratory
Microbiology Section
Soldier Science Directorate

MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.

Claire H Lee

Claire H. Lee

Approved: Gerald Silverman

Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor : Ms. L. Oleksyk

Date: August 27, 1990

Account No.: OMA

Date Received: 05/17/90

Package Type : Thermostabilized Meal Trays

Report No.: 95

Processor : NLABS

PRODUCT	MAL NO.	STORAGE HISTORY
Beef Stew	790	Incubated for 3 mos. at 30C
Beef Stew	791	Incubated for 3 mos. at 30C
Beef Stew	792	Incubated for 3 mos. at 30C
Corned beef hash	796	Incubated for 3 mos. at 30C
Corned beef hash	797	Incubated for 3 mos. at 30C
Corned beef hash	798	Incubated for 3 mos. at 30C
Beef patties	802	Incubated for 3 mos. at 30C
Beef patties	803	Incubated for 3 mos. at 30C
Beef patties	804	Incubated for 3 mos. at 30C
Potatoes with butter sauce	808	Incubated for 3 mos. at 30C
Potatoes with butter sauce	809	Incubated for 3 mos. at 30C
Potatoes with butter sauce	810	Incubated for 3 mos. at 30C

RESULTS:

OTHER DATA	MAL NO.	pH	ODOR/ APPEARANCE
Retorted; Fo=7.46	790	5.61	Normal
Retorted; Fo=7.46	791	5.59	Normal
Retorted; Fo=7.46	792	5.60	Normal
Retorted; Fo=7.91	796	5.54	Normal
Retorted; Fo=7.91	797	5.51	Normal
Retorted; Fo=7.91	798	5.52	Normal
Retorted; Fo=7.27	802	5.90	Normal
Retorted; Fo=7.27	803	5.76	Normal
Retorted; Fo=7.27	804	5.88	Normal
Retorted; Fo=7.66	808	5.35	Normal
Retorted; Fo=7.66	809	5.38	Normal
Retorted; Fo=7.66	810	5.36	Normal

Microbiology Analytical Laboratory
Microbiology Section
Soldier Science Directorate

MICROSCOPIC EXAMINATION	AEROBIC PLATE COUNT	YEAST AND MOLD
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.

Claire H Lee
Claire H. Lee

Approved: Gerald Silverman
Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor :	Ms. L. Oleksyk	Date:	September 6, 1990
Account No.:	OMA	Date Received:	5/23/90
Package Type :	Thermostabilized Meal Trays	Report No.:	96
Processor :	NLABS		

PRODUCT	MAL NO.	STORAGE HISTORY
Chicken a la king	814	Incubated for 3 mos. 30C
Chicken a la king	815	Incubated for 3 mos. 30C
Chicken a la king	816	Incubated for 3 mos. 30C
Chicken breasts in gravy	820	Incubated for 3 mos. 30C
Chicken breasts in gravy	821	Incubated for 3 mos. 30C
Chicken breasts in gravy	822	Incubated for 3 mos. 30C

RESULTS:

OTHER DATA	MAL NO.	pH	MICROSCOPIC EXAMINATION
Retorted:Fo=7.52	814	5.94	Negative
Retorted:Fo=7.52	815	6.05	Negative
Retorted:Fo=7.52	816	6.05	Negative
Retorted:Fo=7.92	820	5.88	Negative
Retorted:Fo=7.92	821	5.96	Negative
Retorted:Fo=7.92	822	6.00	Negative

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples are commercially sterile.

Claire H Lee
Claire H. Lee

Approved: Gerald Silverman
Gerald Silverman

Microbiology Analytical Laboratory

Microbiology Section
Soldier Science Directorate

Requestor : Ms. L. Oleksyk
Account No.: OMA
Package Type : Thermostabilized Meal Trays
Processor : NLABS

Date: May 14, 1990
Date Received: 04/27/90
Report No.: 41

RESULTS:

PRODUCT	MAL NO.	pH	AEROBIC PLATE COUNT	YEAST AND MOLD
Diced ham w/ potatoe	471	6.00	<10	<10
Diced ham w/ potatoe	472	5.96	<10	<10
Diced ham w/ potatoe	473	5.95	<10	<10
Ham omelet	477	6.09	<10	<10
Ham omelet	478	6.08	<10	<10
Ham omelet	479	6.15	<10	<10
Ham slices	483	6.12	<10	<10
Ham slices	484	6.10	<10	<10
Ham slices	485	6.11	<10	<10

Aerobic plate counts are given as colony forming units per gram of sample
TNTC=Too numerous to count

COMMENTS:

These samples were incubated for 10 days at 30C; no swelling occurred.
These samples are commercially sterile.
Conducting a long term storage study for 3 mos. at 30C.
All samples were retorted at 240F and the Fo were > than 6.00.

Claire H. Lee

Approved: Gerald Silverman

APPENDIX C

EXCERPTS FROM
MIL-SPEC (PROPOSED)
PACKAGING & ASSEMBLY OF
TMT RATION

3. REQUIREMENTS

3.1 First article. When specified, a sample shall be subjected to first article inspection (see 4.3, 6.2 and 6.3).

3.2 Components and materials.

3.2.1 Food product. The food product to be packaged and assembled shall be formulated and thermoprocessed as specified in the TMT Products Specification.

3.2.2 Retortable food container.

3.2.2.1 Container material. The container material shall be a multiple layer coextruded, polymeric structure consisting of: structural resin layer/regrind layer/adhesive/barrier resin layer/adhesive/regrind layer/structural resin layer, as shown in Figure I. Alternatively, a multiple layer coextruded material may be used without the regrind layers. The structural resin shall be pigmented white polypropylene. Talc-filled polypropylene may be used to enhance the heat distortion characteristics of the container. The regrind layer shall be composed of trim scrap containing barrier resin. The barrier layer shall be either ethylene vinyl alcohol (EVOH) or polyvinylidene chloride (PVDC) as long as it satisfies the barrier requirements specified in 3.2.2.2. The barrier layer must have a minimum thickness of 0.001". Adhesives must maintain adequate cohesive strength between layers and prevent delamination in the coextruded product and in post retorted products. Desiccant may be added to the tie layers. The material must be suitable for steam/water retorting using overpressure. All materials shall conform to requirements, as applicable, of Federal Food, Drug, and Cosmetic Act as amended and regulations promulgated thereunder. A certificate of conformance shall be furnished to certify compliance with these requirements.

3.2.2.2 Container fabrication and design. The containers shall be fabricated by using conventional solid-phase or melt-phase thermoforming processes, provided the thermoforming method does not result in warpage of the container during retort. The containers shall be fabricated in two sizes. They shall be rectangular in shape and slightly tapered with rounded corners. Approximate inside dimensions of the smaller size container shall be 4-3/4 inches in length, 3 inches in width and 1-1/4 inches in depth and shall have a practical capacity of approximately 7.5 fluid ounces. The outside dimensions, including flange, shall be no more than 5-1/4 inches in length and 3-1/2 inches in width. The outside bottom dimensions of this container shall be 4-1/2 ± 1/8 inches in length and 2-7/8 ± inches in width. Approximate inside dimensions of the larger size container shall be 5-1/2 inches in length, 3-7/8 inches in width and 1-1/4 inches in depth and shall have a practical capacity of approximately 11.5 fluid ounces. The outside dimensions, including flange, shall be no more than 6-3/8 inches in length and 4-5/8 inches in width. The outside bottom dimensions of this container shall be 5-1/4 ± 1/8 inches in length and 3-1/2 ± 1/8 inches in width. The outside height of both containers shall be 1-3/8 ± 1/8 inches. The container wall thickness shall be no less than .015". The gross oxygen transmission rate per container at 70°F at 70% RH shall be no more than 0.0003 cc O_2/pkg/day, ATM. The gross water vapor transmission rate shall be no more than 0.008 gm H_2O/pkg/day. A certificate of conformance shall be furnished to certify compliance with the thickness and barrier requirements.

4.5 Methods of inspection.

4.5.1 Lidding materials thickness tests. Any failure of a sample average thickness to conform to the specified lamina thickness shall be considered a test failure.

4.5.1.1 Polyolefin. The thickness shall be determined in accordance with L-P-378 except that a machinist's micrometer may be used, provided its graduations and accuracy conform to the requirements specified in L-P-378. The average thickness of the samples shall be reported to the nearest 0.0001 inch.

4.5.1.2 Aluminum foil. The thickness shall be determined in accordance with the procedure specified in QQ-A-1876. The average thickness of the samples shall be reported to the nearest 0.00001 inch.

4.5.1.3 Polyester. The thickness shall be determined by a gauge measurement as specified for the polyolefin lamina in L-P-378, except that the tolerance shall be ± 14%. The average thickness of the samples shall be reported to the nearest 0.00001 inch.

4.5.2 Residual gas volume test. Volume of residual gas may be determined in accordance with method 4.5.2.1 or 4.5.2.2.

4.5.2.1 Destructive method. Volume of residual gases shall be determined as follows. The samples for test shall be opened under $75^{\circ} \pm 5^{\circ}F$ water and the gases shall be collected by water displacement in a graduated cylinder or other calibrated tube. The volume of the gases shall be reported to the nearest 0.1 cubic centimeter. Any residual gas volume exceeding 10.0 cubic centimeters shall be considered a test failure.

4.5.2.2 Non-destructive method. A Meade tester or similar modified vacuum desiccator type apparatus shall be used to test the containers. Individual samples, suspended from a beam-type balance shall be weighed in the water (completely submerged) of the test apparatus to the nearest 0.1 gram. The temperature of the water during the test shall be $75^{\circ}F \pm 5^{\circ}$. If the sample does not sink, a small arbitrary weight shall be attached to the sample. After weighing, the individual samples (weight attached if used) shall be detached from the balance and resubmerged in the water of the tester. With the lid in place, the sample shall be made to float by reducing the air pressure over the water by means of a vacuum pump. The reduced pressure in millimeters of mercury at which the sample just floats below the water surface (still completely submerged) is recorded as the pressure at neutral buoyancy. When making the above determinations, care should be exercised to prevent small bubbles of air from adhering to the sample. The atmospheric pressure in millimeters of mercury shall be measured with a barometer. The data from the three determinations shall be used to calculate the volume of residual gases to the nearest 0.1 cubic centimeter as follows:

$$\text{Volume of residual gases } (cm^3) = \frac{\text{Pressure at neutral buoyancy} \times \text{weight in water (g)}}{\text{ATM pressure} - \text{Pressure at neutral buoyancy}}$$

Any residual gas volume exceeding 10 cubic centimeters shall be considered a test failure.

4.5.3 Seal strength test. The filled and sealed containers shall be tested for closure seal strength in accordance with procedures specified in Method A or B of ASTM D-882. Three adjacent specimens, at least half inch wide, shall be cut from each seal on the container. The results shall be reported to the nearest 0.1 pound per linear inch. The average seal strength of the seal shall be calculated by averaging the test results of the three test specimens cut from the seal. Any test specimen failing to meet the individual test specimen seal strength requirement of 3.2.2.4 or the average seal strength requirement of 3.2.2.4 shall be scored as a defect. The lot size shall be expressed in containers. The sample unit shall be one filled and sealed container. Samples from seal strength test shall be examined under a magnifier. Any sample with the seal depths touching the barrier layer is a defect.

4.5.4 Leakage test. Filled, sealed and thermoprocessed containers shall be tested for leakage in accordance with method 4.5.4.1 or 4.5.4.2.

4.5.4.1 Vacuum test (ASTM D 3078). The filled, sealed and processed container shall be submerged in water in a transparent vacuum chamber that is capable of withstanding approximately one atmosphere pressure differential The vacuum chamber shall be fitted with a flat-vacuum-tight cover. A vacuum gauge, an inlet tube from a vacuum source, and an outlet tube to the atmosphere, shall be sealed into the cover. The inlet and outlet tubes shall be equipped with hand valves. Attached to the underside of the cover shall be a transparent plate that will closely approximate the inside diameter of the container and be such a distance from the top of the container that when it is 2/3 filled with water, the attached plate will be positioned 1 inch under the water. The sample container shall be submerged in water so that the uppermost surface of the container shall be covered by not less than 1 inch of water. The cover shall be set on the chamber, the outlet valve closed and the vacuum turned on until 27 inches of mercury is reached. The vacuum shall be on hold for a minimum of 30 seconds. During the rise in vacuum and the hold, the submerged sample shall be observed for leakage in the form of a steady progression of bubbles from the sample container. Isolated bubbles caused by entrapped air are not considered to be leaks. Any leakage is a defect.

4.5.4.2 Air pressure test. Using a small compressor or house air line with 0-10 psi gauge, the air pressure shall be set to 6 psi and the source of compressed air shall be turned off. The lid of the sample container shall be punctured with a hollow puncture needle affixed to the air line. The needle shall puncture the container lid through a sealant compound or small septum that has been applied to the container and has been allowed to set in accordance with the manufacturers instructions (see 6.4). After puncturing the lid, the source of compressed air shall be turned on. Observe bulge of lid for 30 seconds, paying strict attention to areas of suspect leakage. Lid should not burst at 6 psi for 30 seconds. If pressure drop occurs, a steady stream of air escapes, the container bursts, or any seal yields more than 1/16 inch, the container shall be considered defective.

4.5.5 Sterility test. Filled, sealed and thermoprocessed containers shall be tested for commercial sterility. Samples of containers shall be incubated at temperature and length of time period as specified by Food Safety Inspection Service (FSIS) prior to testing. Any evidence of container swelling or off-odor shall be considered a test failure. The product shall not be shipped from the contractor's plant prior to the successful completion of the required sterility (incubation) test as determined by the proper inspection agency. A sterility test failure shall result in official retention of the lot's production of that product by the proper inspection agency. Records of commercial sterility shall be retained by contractor and be made available upon request.

4.5.6 Oxygen transmission rate through package. The filled, sealed and processed container shall be tested to determine oxygen transmission rate through the total package. Oxygen transmission through the total package may be measured in accordance with ASTM procedure D 3985, F 1307, or with any complete package testing equipment (see 6.4) which is sensitive enough to measure oxygen transmission rates through high barrier materials (resolution of 0.000005 through 0.0001 cc/pkg/day with a 1% repeatability of the reading). Oxygen transmission rates through the final package must meet or exceed the requirements listed in 3.2.2.2.

4.5.7 Water vapor transmission rate through package. The filled, sealed and processed container shall be tested to determine water vapor transmission rate through the total package. Water vapor transmission through the total package may be measured in accordance with ASTM procedure F 372, F 1249, or with any complete package testing equipment (see 6.4) which is sensitive enough to measure water vapor transmission rates through high barrier materials (resolution of approximately 0.00005 gm/pkg/day with a repeatability of 2-3% in 0.035 to 0.12 gm/pkg/day range). Water vapor rates through the final package must meet or exceed the requirements listed in 3.2.2.2.

5. PACKAGING

5.2 Packing. Packing shall be level A, B or C as specified in the contract.

5.2.1 Level A packing of assembled rations. Ten ration trays of the same menu shall be packed in a snug fitting fiberboard box according to the configuration in Figure V constructed and closed in accordance with style RSC-L-SL, grade V2s of PPP-B-636, except metal fasteners shall not be used in the closure of the flaps, the gap between top or bottom flaps shall not be more than 1/2 inch wide, and adequacy of the closure shall be determined by testing as specified in 4.4.6.4. The inside of each shipping container shall be fitted with an open box liner conforming to grade V3c of PPP-B-636. The open liner shall be designed in the configuration as shown in Figure V. The approximate inside dimensions of the container shall be 18 inches in length, 11-1/4 inches in width and 8 inches in depth. The outside of each shipping container shall be fitted with a sleeve conforming to grade V2s of PPP-B-636. The height of the box liner shall be equal to the full inside depth of the box (-1/8 inch). Inner flaps of the box may be closed with two strips of hot melt adhesive per flap, provided the closure meets the test requirements of 4.4.6.4. As an alternative to body joint metal fasteners, adhesive conforming to MMM-A-250, applied in accordance with the "adhesive joint" requirement of PPP-B-636, may be used to secure the manufacturer's joint of the V2s box. As an alternative to sleeve joint metal fasteners, adhesive conforming to MMM-A-250 may be used for securing the joint, except the overlap shall be a minimum of 3 inches wide.

The adhesive sleeve joint shall cover a minimum of 90 percent of the sleeve overlap area. The shipping container shall be reinforced in accordance with the appendix of PPP-B-636, except pressure sensitive adhesive, filament reinforced tape shall not be used. Instead, two straps positioned girthwise to divide the box into units of equal length shall be used.

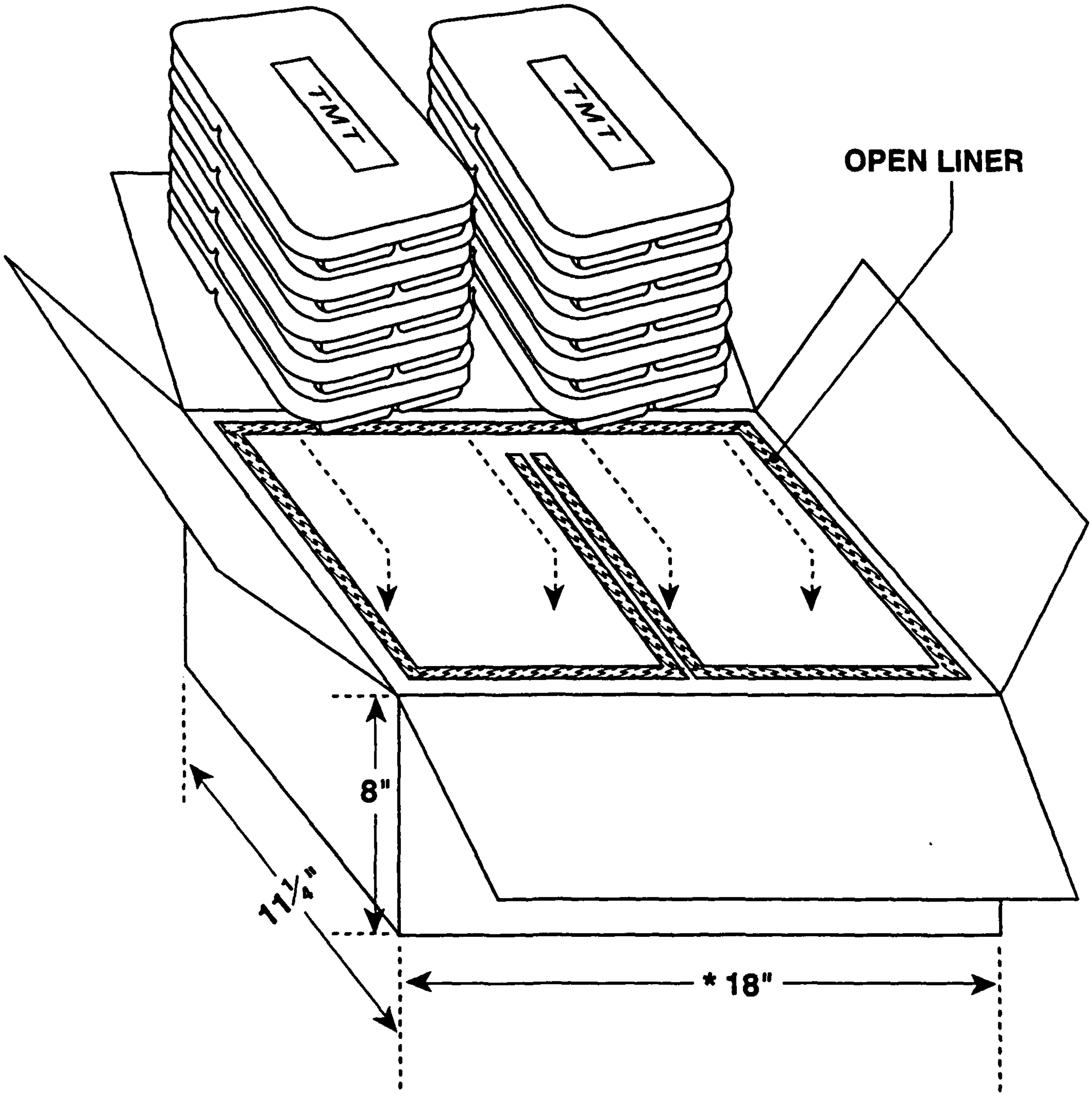
5.2.2 Level B packing.

5.2.2.1 Level B packing of assembled rations. Ten ration trays of the same menu shall be packed in a snug fitting fiberboard box, according to the arrangement shown in Figure V, constructed in accordance with style RSC-L, grade V3c of PPP-B-636. The inside of each shipping container shall be fitted with an open box liner and a top and bottom pad conforming to grade V3c of PPP-B-636. The open liner shall be of the type shown in Figure IV. The approximate inside dimensions of the shipping container shall be 18 inches in length, 11-1/4 inches in width and 8-3/8 inches in depth. The height of the box liner shall be equal to the inside depth of the box (-1/8"). Metal fasteners may not be used in closing outer flaps of the box after it is packed. Each shipping container shall be closed in accordance with Method III, taped in accordance with Method V, and reinforced with nonmetallic strapping or pressure-sensitive adhesive, filament reinforced tape in accordance with PPP-B-636.

5.2.2.2 Level B packing of meal components. When ration assembly of components into ration tray is not required in the contract, packing of individual meal components for shipment and storage shall be as follows. Thirty six entree components (11 oz. containers) of the same product shall be packed in a snug fitting fiberboard box constructed in accordance with RSC, grade V3c of PPP-B-636. Approximate inside dimensions of the box shall be 13-3/8 inches in length, 12-3/8 inches in width, and 8-3/4 inches in depth. The entree components shall be packed in 6 layers with 6 entrees per layer as shown in Figure V. Pads conforming to grade V3c shall be fitted between layers and in the top and bottom of the inside of box. Thirty six starch, vegetable or dessert components (7.5 oz containers) of the same product shall be packed in a snug fitting fiberboard box, constructed in accordance with RSC, grade V3c of PPP-B-636, with approximate inside dimensions of 15-3/4 inches in length, 10 inches in width, and 6-3/8 inches in depth. The components shall be packed in 4 layers with 9 components per layer as shown in Figure VI. Pads conforming to grade V3c shall be fitted between the layers and in the top and bottom of inside of box. When metal fasteners are used in the box manufacturer's joint, the fasteners shall be completely covered on the inside of the box with pressure sensitive tape. Each shipping container shall be closed in accordance with Method III, taped in accordance with Method V and reinforced with nonmetallic strapping or pressure-sensitive adhesive, filament reinforced tape in accordance with PPP-B-636.

5.2.3 Level C packing for shipment to ration assembler. Packing of ration components for shipment to ration assembler shall be as follows. Not more than 50 meal components of one product shall be packed in a manner to ensure carrier acceptance and safe delivery at destination at the lowest transportation rate for such supplies. The shipping container shall be in accordance with the National Freight Classification or the Uniform Freight Classification, as applicable, except fiberboard containers shall be closed in accordance with Method II, as specified in PPP-B-636. When metal fasteners are used in the manufacturer's joint or in the set up of the fiberboard box, the fasteners on the inside of the box shall be covered with tape to protect contents from mechanical damage.

SHIPPING CONTAINER - ASSEMBLED RATIONS

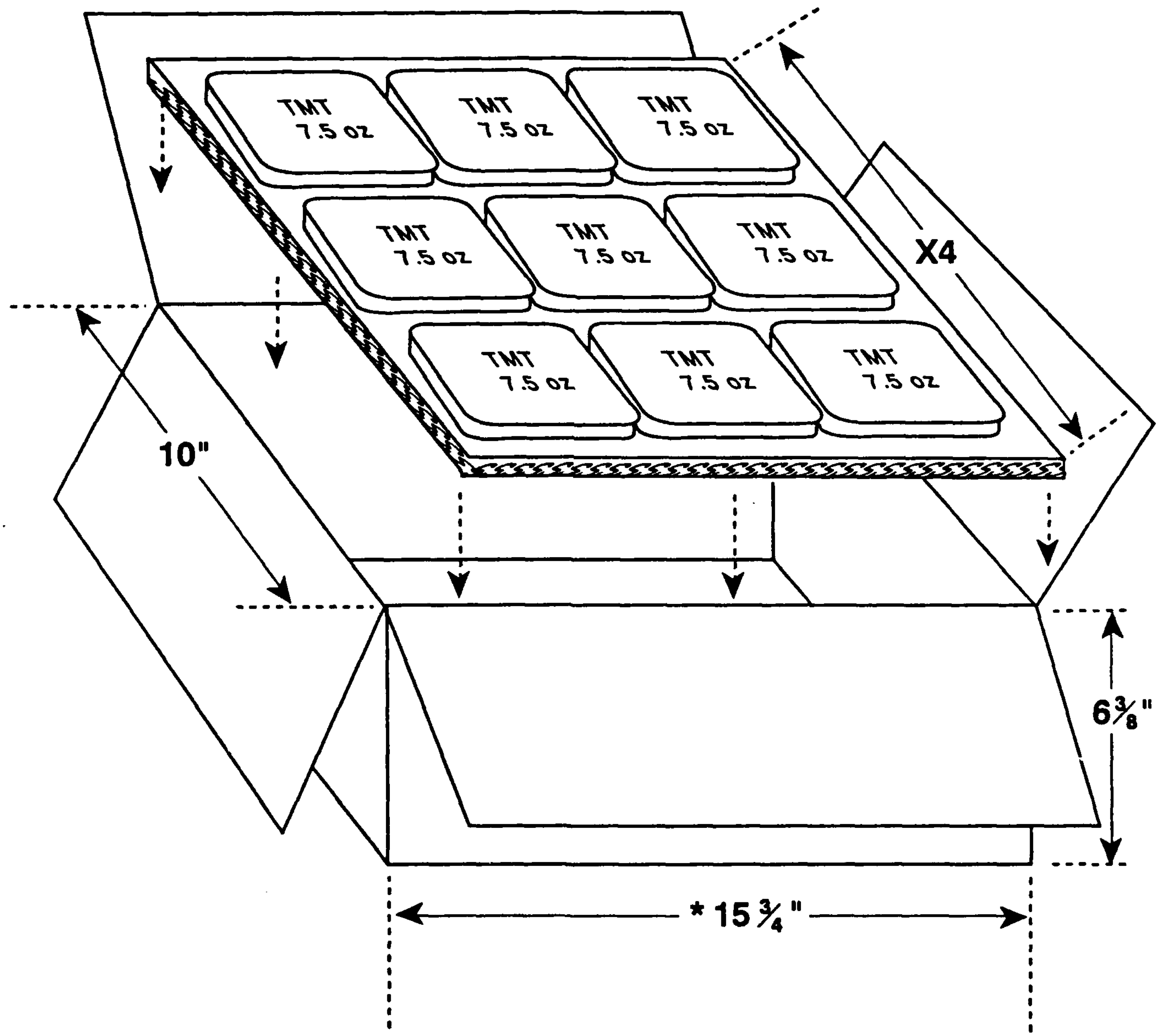


* APPROXIMATE INSIDE DIMENSIONS

FIGURE C1

SHIPPING CONTAINER - 7.5 oz COMPONENTS

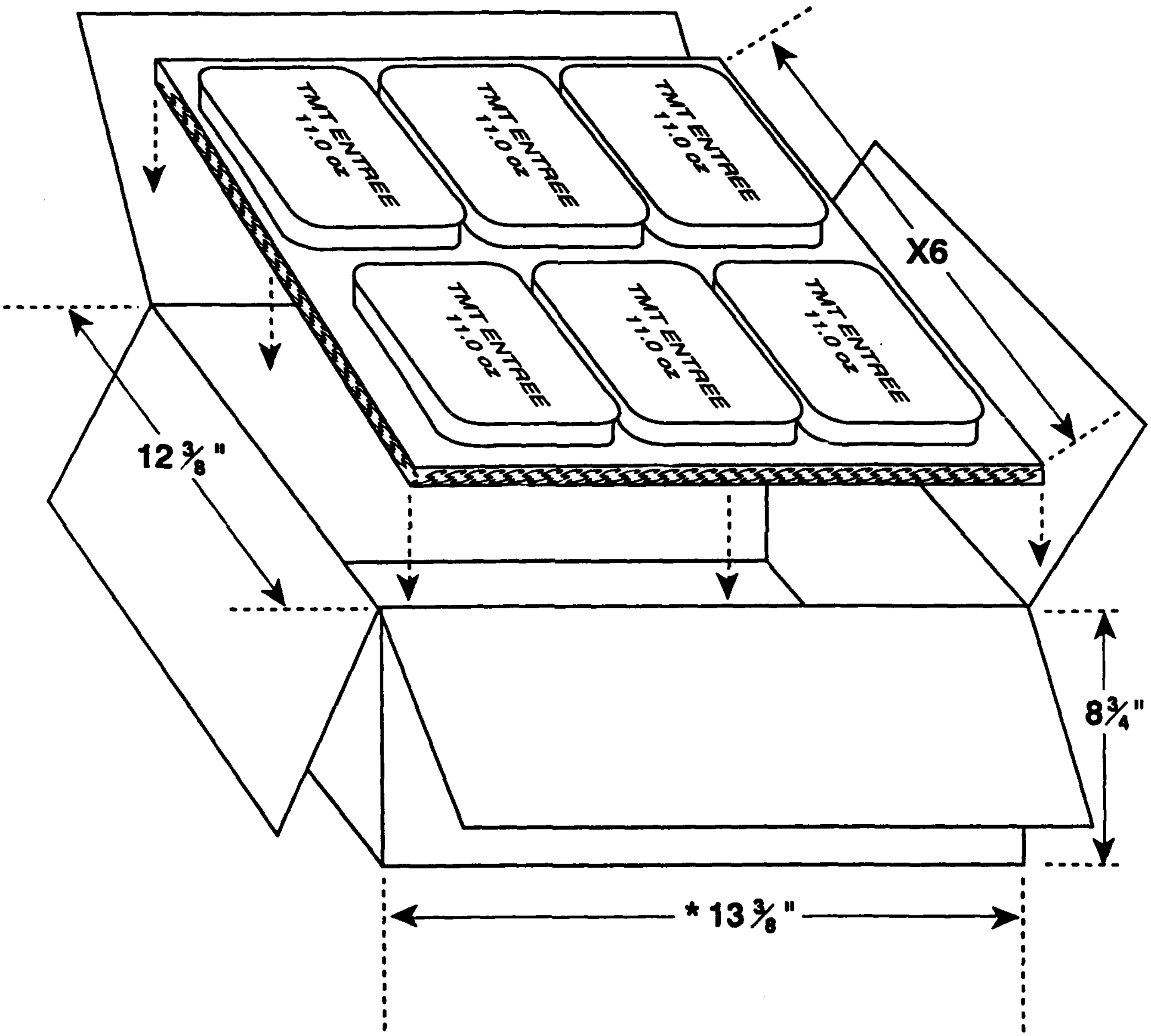
(STARCH, VEGETABLE OR DESSERT)



* APPROXIMATE INSIDE DIMENSIONS

FIGURE C 2

SHIPPING CONTAINER - ENTREE (11.0 oz) COMPONENTS



* APPROXIMATE INSIDE DIMENSIONS

FIGURE C 3

BIBLIOGRAPHY

Natick Laboratory Notebook #8569

Defense Technical Information Center, Work Unit Summary Report on Thermostabilized Meals, No. T43378, May 17, 1989.

Defense Technical Information Center, Technical Report Summary Report on Thermostabilized Meals, No. 066574, May 17, 1989.

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